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Magdalena L. Briones

Burruss McDaniel

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Entomology- Zoology Department
Agricultural Experiment Station
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Brookings

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This group of mites contains individuals known as gall mites, blister mites, rust mites, or bud mites. They are extremely small forms and cause damage to plants by their feeding habit and their ability to spread certain pathogenic fungi called rusts. Recently it has been established that some members of this family are capable of transmitting certain plant viruses.

These mites have long been known as pests of orchard trees. They will most readily be observed forming galls on many of our common shade trees such as elms, oaks and maples. The species, *Eriophyes tulipae*, wheat curl mite, is a known vector of wheat streak mosaic virus and has been collected on *Agropyron triticum* throughout western South Dakota. *Abacarus hystrix*, grain rust mite, has been found to be associated with three species of grasses in both eastern and western South Dakota. *A. hystrix* is known to transmit two types of virus diseases to grasses in addition to its role in spreading rust spores.

Eriophyid mites are very small plant feeders and will be overlooked by the casual observer. The most noticeable structure indicating the presence of this pest will be the galls, blisters, or the deformation of the bud. Even though the galls and blisters are relatively small, each gall or blister may contain several hundred to several thousand individual mites. Many other plants not showing these symptoms will have free-living species which may be associated with stunted plants or the greenish mottling or streaking found on the leaves of various grasses.

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Eriophyid Plant Mites of South Dakota

MAGDALENA LOPEZ BRIONES and BURRUSS MC.DANIEL*

INTRODUCTION

Mites of the superfamily Eriophyoidea have been long known as pests of deciduous trees in the United States. Parrott et a l. (1906) reported damage to many varieties of apples and pears by eriophyids. In California, damage to commercial varieties of citrus was recognized more than 30 years ago (Keifer 1939); in Florida damage to citrus was reported earlier (Yothers and Mason 1930). The role of the eriophyid mites as vectors of plant viruses has become the subject of intensive attention in the past two decades in North America. Slykhuis (1953) and Wilson et al. (1955) are largely credited for bringing this renewed interest in eriophyid mites. Slykhuis and Wilson's discoveries of the wheat curl mite, *Eriophyes tulipae* Keifer, as vector of wheat streak mosaic virus (WSMV) and *Phytoptus insidiosus* (Wilson and Keifer) as vector of peach mosaic virus prompted many plant pathologists and entomologists to study the bionomics and control.

Prior to this study, these members of phytophagous Acarina were practically unkown in South Dakota. Only five species had been recorded in this state (White 1966). Included in these were two of the most economically important species, *E. tulipae* K. and *Abacarus hystrix* (Nalepa). *E. tulipae* is the vector of WSMV (Slykhuis 1953), wheat spot mosaic (Slykhuis 1956) and wheat spot chlorosis pathogen (Nault et al. 1970). This mite is also the causal agent of the kernel red streak of corn, a phytotoxemia (Nault et al. 1967, Slykhuis et al. 1968). *A. hystrix* transmits rye grass mosaic virus (Mulligan 1960) and agropyron mosaic virus (Slykhuis 1969).

*Respectively, former graduate research assistant, present address: 1822 Bridge Street Number 6, Los Angeles, California 90033; and professor of entomology, Department of Entomology-Zoology, South Dakota State University.

Considering the economic importance of this ubiquitous group of mites, their worldwide distribution, importance in the states surrounding South Dakota, and the fact that South Dakota is a major agricultural state, the urgent need to establish the identity of these species becomes apparent.

Results of 3 years of collecting during summer months, mainly in the southeastern portion of South Dakota, are included here. Of the 19 genera collected in South Dakota, there are 48 species; 6 herein named and described. It is hoped that this study of the Eriophyoidea of South Dakota will constitute an effective spring-board for taxonomists as well as for those interested in agricultural factors implicating these mites.

Eriophyids are very small, about 90u to 300u in length and are often overlooked by inexperienced observers. Therefore an additional purpose of these studies is to provide information on techniques of collection, preservation, slide preparation and detection of eriophyid presence on deciduous trees, shrubs and grasses.

According to Hassan (1928), Reaumur in 1737 was the first to record damage attributed to an eriophyid of the linden tree. It was believed they were insect larvae. More than 100 years later, Dujardin and Landois recognized that these minute animals were actually mites. Lamlois did the first thorough study of the biology of *Columerus vitis* (Pagenstecher), an important pest of grapes.

In the United States the earliest account of the activities of the mites was the description of the pouch gall mites on silver maple by Shimer (1869). The following year, Riley noted a species which caused "nail galls" on *Acer saccharum* L. and Ryder reported a mite taken from "forest epidermal growths" on maple leaves, but did not describe it (Hodgkiss, 1930).

Garman (1883) published the first comprehensive classification of species of Eriophyoidea known in America at that time. Later, Banks (1904) reported 15 species of mites on five species of maple. Hodgkiss (1930) described a number of new species of maple mites in New York.

According to the earlier ideas these animals comprised one genus, *Phytoptus* established by Dujardin (1851). This group of mites was known as Phytoptidae, but later workers accepted *Eriophyes* Von Siebold which had one month's priority over *Phytoptus*. The former designation has given rise to some confusion in American literature since earlier workers followed that classification. Subsequent morphological studies by an Austrian, Alfred Nalepa, showed that distinct generic differences existed for which new genera were erected.

The present taxonomy of the Eriophyoidea is largely based on the extensive studies by Nalepa from 1887 to 1929. He contributed more than 50 papers on the taxonomy of eriophyid mites. Although many of Nalepa's "species" were based on host relationships, and his drawings would be considered inadequate by later standards; his were the first comprehensive descriptions of eriophyids.

H. H. Keifer is largely responsible for the classification of Eriophyids found in North America and many other geographical areas. He began his study in 1937 in California and his contributions for over 30 years have significantly advanced the knowledge with respect to the classification of the Eriophyoidea. Keifer's review of California Eriophyoidea (1952) based in part on Nalepa's concept utilizes also the structure of the rostrum, oral stylets, seta number on the shield and abdominal setae as family and subfamily characteristics.

Subsequent to Nalepa, other workers in Europe, most notably Liro and Roivainen, described many genera and species from Europe. These two workers published a comprehensive manual, Eriophyids of Finland (1951). Other notable contributors to the continuous growth of eriophyid taxonomy are: Boczek in Poland, Farkas in Hungary, Channavasavana in India, Carmona in Portugal, C. C. Hall in Texas who worked with Kansas mites, Lamb in New Zealand, and Wilson and Oldfield in California.

Unfortunately, many of the descriptions of eriophyids prior to 1939 are inadequate by present standards. Most species names prior to Nalepa's work were based on the nature of the work by the mites. The mounted specimens of early described type species have either completely deteriorated or have been destroyed, and rather inadequate descriptions, usually including only general illustrations of the ventral or dorsal aspect of the mites were made. Keifer's (1942) discovery that certain species have females of two morphological types, exposed still another problem in correlating new and old descriptions of eriophyids. The present confusion regarding this status of certain forms may only be resolved when European and American eriophyid populations are studied in some detail, both morphologically and biologically. It is probable that only 20 percent of the eriophyid fauna of the world has been discovered to date, as evident in the numerous undescribed eriophyid collections made by Wilson (personal communication 1972) from Mexico and the Philippines. There is now a need of careful study for the population variation and adequate interpretation of species.

Systematic Relationship of Eriophyoidea To Oher Acari

Ewing (1928) and Wooley (1961) reviewed the literature on the relationships of eriophyid mites to other Acari. The discussion that follows is principally based on these papers. According to Wooley (1961), Dahl in 1910 stated that the tendency of the Tarsonemidae towards reduction of the last pair of legs indicates a close relationship to the Eriophyids. Banks in 1915, agreed with Dahl's hypothesis and added that the ability of Tarsonemidae to cause swellings and deformities of plants indicated a close relationship to eriophyids that are known to cause galls. On the other hand, Oudemans in 1910 related this group to the nymphal stage of Tetranychidae. Later, Ewing said that the gall mites form a highly aberrant and specialized group which has originated through the process of morphological changes and adaptations from the Phytoptipalpidae. He regarded the Phytoptipalpidae as a transitional group between the Eriophyoidea and Tetranychidae. Although, Ewing did not state that the gall mites evolved directly from Phytoptipalpidae, he conceded that there is evidence existing that these two are very closely related.

Baker and Wharton (1952) state that the transverse genital opening of the Eriophyoidea and Phytoptipalpidae indicated relationships since these are the only closely related families that possess this type of genital opening; others have longitudinal slits. The genitalia of the Eriophyoidea is located anteriorly a short distance from the coxae, while that of the Phytoptipalpidae is caudad. According to Baker and Wharton (1952) this difference may not be significant, since there may have been a coalescing of body segments posteriorly in the Phytoptipalpidae. Thor in 1928 (Wooley 1961) considered Demodicidae as more closely related to Eriophyoidea on the basis of their annulated body, simple mouth parts, short legs and absence of tracheae and stigma. Hall (1967a), however, states that such resemblances may be the result of parallel evolution of two unrelated or only distantly related line ages.

The family Tetranychidae is possibly the only group of Acarina that indicate close relationship with the Eriophyoidea on the basis of their terminal leg structure. In Tetranychidae, each claw terminates in a pair of tenent hairs or is bordered with combs of tenent hairs which may be the counterpart of the Eriophyoidea featherclaws. The empodia is claw-like or pad-like, which are rarely absent in Tetranychidae and are often divided distally, and may correspond to the divided featherclaws of certain eriophyids. Scanning electron micrographs of featherclaws of *E. tulipae* and *Aculops maximilianae* n. sp. show fine structures that have never been reported nor understood in this group. Perhaps utilization of the scanning electron microscope to study the terminal leg structures in mites of these two families may reveal further relationships between these groups.

There is considerable variation in the hierarchial position given to this group of mites. Hughes (1958) arranged the Eriophyoidea in a separate suborder Tetrapodili, while Krantz (1970) ranks this group under cohort Tetrapodilina. In the present investigation, the classification of Krantz is followed:

Order:Acariformes
Suborder:Prostigmata
Cohort:Tetrapodilina
Superfamily:Eriophyoidea

Phylogeny cannot be directly observed, since it is something that happened in the past and must be inferred from the available evidence. Nevertheless, despite the interpretation and evaluation by these workers, we know very little of the systematic relationships of the Eriophyoidea to other members of the Acari. These are still controversial and have been subject to personal interpretations and speculations. This is not surprising at all since Acarology is still in its beginning. There is an almost complete lack of understanding of the eriophyoid physiology and embryology. A study of the last two aspects may throw light on the many puzzling questions of relationships to other members of the Acarina.

General Morphology of Eriophyid Mites

The external appearance and structures of the eriophyids are generally quite similar, however, there are two main groups recognized; the more or less wormlike spindle form and fusiform group; the rather broader and chunkier, often flat type. The first group contains the majority of the described forms and economically important species. The latter group includes some rare forms that are ddifficult to correlate with other known eriophyid mites. Two examples of these extreme forms are from the Philippines. *Scolocenus spiniferus* Keifer (Keifer 1962, Briones and Sill 1963), is found on coconuts. *S. spiniferus* possesses a large lateral expansion on the anterior part of the abdomen. The other mite recently described is taken from *Artocarpus* sp.. This mite features a fused anterior dorsal portion of the abdomen that projects as a large hump at the back, giving a general triangular appearance to the whole body.

Eriophyid mites are easily recognized regardless of the kinds because of their unique body structure and annulate abdomen. Their main distinction from other members of the Acarina taxon is the possession of only two pairs of legs located anteriorly. The body of the eriophyid mite is divided into two major parts, the gnathosoma and idiosoma (the thanosome and telosome of Keifer). The gnathosoma inclndes that part which is covered dorsally and laterally by a shield which may project to a varying degree over the base of the rostrum. The gnathosoma also inclndes the whole mouth parts or gnathosome which consists of a frontal beak-like structure and adjacent appendages, collectively termed the rostrum. According to Shevtsenko and Silvere (1968) it consists of epistoma, labrum and appendages of chelicerae and pedipalpal segments. The internal structures identified and described by Keifer (1959) (Plate 42) which are parts of the gnathosoma are: pump brace, hinge, pharyngeal pump and motivator. The rostrum is composed of the palpi that form a dorso-anterior groove in which lie the following mouth parts: chelicerae, cheliceral guide, auxiliary stylets, oral stylets and cheliceral sheaths. The needle-like cheliceral stylets are fixed and the terminal segments of the palpi telescope or fold back to enable the stylet to penetrate epidermal layers of the surface of the host during feeding. Studies made by Orlob (1967) of *E. tulipae* K. reveal that the stylets of this mite are able to penetrate the epidermal cells of wheat to a depth of .5u. An additional detailed interpretation of the mouth parts is given by Shevtsenko and Silvere (1968) in Russian.

The shield or dorsal plate of the cephalothorax is quite variable in shape and the sculptural design is of taxonomic importance.

The idiosoma, composed of the thanosome and telesome (abdomen) is transversely annulated.

Some species have a body evenly annulated all around. In the others, the number of ventral annuli on sternites, outnumbers those on the tergites. The annuli possess "microtubercles." The size, shape and concentration of the microtubercles are taxonomically important when combined with other attributes.

The abdomen is terminated by what appears to be a bilobed "sucker." Wilson (personal communication) observed that the mites utilize their anal setae to erect themselves. The anal setae are generally long in most of the mites and are curled around the leaf surface trichomes thus holding the mite in an upright position. Perhaps mites excrete some sticky substance through the anal opening and the pair of anal setae act as anchors enabling the mite to assume the upright position. Studies made by Whitmoyer et al. (1972) of the anal "sucker" of *E. tulipae* K. using an electron scanning microscope showed that it is composed of outer and inner foldings. According to these workers, it is the outer set that appear to function as clasping structures, whereas the inner fold protects the anal opening.

The chaetotaxy of the eriophyids is very simple compared with the other phytophagous mites. Generally, eriophyids have a regular setal pattern, nevertheless, their location, presence of particular setae are useful criteria for separating families, subfamilies and genera.

The relative lengths of the setae are often extremely useful in determining species within a genus. However, too often due to the mounting techniques and handling of specimens, setae are broken and may appear to be short. Therefore, a large number of specimens in a given population must be carefully studied to determine the actual length of these setae. The family Nalepellidae is easily recognized by the presence of one or two anterior shield setae in addition to the setae on the posterior part of the shield. Members of the other two families, Eriophyidae and Rhyncaphytoptidae may have none or only one pair on the dorsal shield. The dorsal shield setae are usually borne on tubercles. The axis of these dorsal tubercles, and the consequent direction that the dorsal setae project furnish important generic characters. In all the known Nalepellidae, the anterior shield setae point forward. Typically, Eriophyidae possess four pairs of abdominal setae; lateral setae, (LS); ventral setae I, (VS1); ventral setae II, (VS2); and ventral setae III, (VS3). The lateral setae are on the sides and slightly behind the rear margin of the shield. The ventral setae are behind the lateral setae and the last pair is on the 5th to the 9th annulation from the rear. Some species belonging to the subfamilies Nalepellinae, Phytocoptellinae and Sierraphytoptinae possess subdorsal setae slightly dorsal to the region where the lateral setae are normally located. Often the caudal lobes also have a pair of minute "accessory setae" (about 2u to 5u long) between and slightly behind the caudal setae. The presence and size of the "accessory setae" are sometimes taxonomically useful characters.

The genital plate with its thanosome genital aperture is a short distance behind the hind coxae. In the female, the external part of the genitalia consists of a semicircular, boxlike area with a coverflap which is arched posteriorly. The coverflap exhibits variable designs such as single or double longitudinal lines, crescentic lines or granular designs or it may even be smooth. Surface detail of the coverflap is of some taxonomic value when combined with other characters at the species level. Although the function of the genital coverflap is not known, Keifer (personal communication) has speculated that the coverflap may act as a scooping mechanism to gather spermatophores.

Posterior and lateral to the coverflap is found a pair of genital setae. The length of these setae may be useful in some specific diagnoses. Internally there is the apodeme and to this apodeme are attached a pair of globose structures which Oldfield et al. (1970) recently proved to be spermathecae.

Keifer and other workers have often excluded the males in developing the taxonomy of eriophyids, thus, they are much less understood than the female. Males are common and they play an important role in eriophyid reproduction (Oldfield & Newell, 1973). They have been observed occurring in large numbers in some species and obviously the study of their internal genital structure will be significant in eriophyid taxonomy.

In more than half a dozen different species observed during this study, there appears to be a pair of globose organs attached at the end of the glandular tube of the male internal genitalia, Plate 13, Fig. 8 and Plate 18, Fig. 6. Perhaps the techniques of preparation can be improved in later studies to clearly show the actual structure of these. Indication of such organs has also been reported by Hall (1967b). Perhaps these organs may be storage sacs or sources of spermatophores in the male.

The legs of the eriophyids are more or less uniform. They are typically acarine in that they are usually composed of five distinct segments, the coxa, femur, patella, tibia and tarsus. The tarsus is terminated by a "claw" and "featherclaw." The featherclaw is the empodium; it may he simple or it may be divided with its main axis with a variable number of rays branching from it. The number of rays is generally a useful taxonomic character for separating species. However, within a population the number of rays on the featherclaw may not be entirely constant, therefore, a careful examination of a population usually reveals the standard or range. Because, the two opposite rays may super-impose and appear as one in lateral view, the branching of featherclaw is best seen when the mites are in the dorsal or ventral position.

Use of the scanning electron microscope promises to clarify many of the problems encountered in studies of the external morphology of the eriophyids.

For example, the scanning electron micrograph of the featherclaws of *Aculops maximilianae* n. sp. (Plate 8) and *E. tulipae* K. (Plate 23, Fig. 4) shows many details which have not been previously discernible in optical systems. Work thus far with the scanning electron microscope indicates that many of these minute structures may be remarkably constant within a species.

Most eriophyids possess a ventral seta on the femur; thus, the absence of this seta is taxonomically significant. The patella has one seta; usually it is dorsal or occasionally lateral as in some of the Nalepellidae, or the seta is absent as in some of the Rhyncaphytoptidae. The foretibia usually has a dorsal seta but this may be absent in some species. Mites in the Nothopodinae lack the tibia or have the tibia and tarsus fused as in *Floracarus*. Sometimes the lateral foretibial spur is enlarged so as to resemble a claw as in some Nalepellidae. The foretarsi of most eriophyids possess a pair of dorsal setae near the base, and a small seta on the lower, inner side. The hind legs have the same setae as the forelegs except that there are never hind tibial setae.

The so called "claw" on the tip of the tarsus is perhaps not a true claw, but a sensory club.

Life History of Eriophyid Mites

Life histories are generally the same in all eriophyid mites in that they pass through four different development stages, the egg, first nymph, second nymph (including 2 pre-imaginal resting periods) and the adult. Although not yet completely substantiated it is probable that four different types of life cycle may be involved in Eriophyoidea. The simple type involving only one type of female; the complex type, where one female (protogyne) resembles the male and the other female (deutogyne) is morphologically different from the protogyne (Hall 1967a). The third type of life cycle is found where the female may be ovoviviparous. Evidence of ovoviviparity has been observed in *Eriophyes laevis* (Nal.) by Shevtshenko (1957); in protogyne of *Vasates quadripedes* Shimer by Hall (1967b); in an undescribed *Eriophyes* from Chile (Wilson, personal communication). Hall (1967b) citing Burditt et al., observed the same in *Phyllocoptruta oleivorus* (Ashmed) in 1963. Protogyne female of *Eriophyes chondriphora* (Keifer) with nymph inside the body were observed from prepared slides of a South Dakota collection (Plate 17, Fig. 7). An account of the biological forms of the progeny produced by ovoviviparous females is at present completely lacking. The fourth type is represented in the observation made by Oldfield (1969), in *Phytoptus* *emarginatae* (K.) in which no protogyne females have yet been born, thus perhaps a univoltine species.

Despite the increased interest in eriophyids that has taken place in the past two decades, there are still many important aspects concerning the biology and morphology that remain unknown. Their very small size has hampered the elucidation of many details of reproduction, embryology, and physiology.

The means by which sperm is transferred between sexes has recently been shown to be through the agency of spermatophores for at least several species (Oldfield et al. 1970; Oldfield & Newell 1973). These workers showed that females of *Aculus cornutus* (Banks) produced both sexes of progeny after an observed visitation of a spermatophore but produced only males if the spermatophore were unavailable. The discovery clarified the role of the male and perhaps will spur the further study of them. The apparent specific differences in structure of the spermatophores studied by Oldfield et al. (1970) may be of some aid in separating certain subtaxa of the Eriophyoidea.

Distribution and Host Relationships

The extremely small size of eriophyids has hampered efforts to study them in some parts of the world. Although a considerable number of species have been described from Europe, California and Kansas, much of the rest of the world's eriophyid fauna remains unknown.

A number of species are recorded from Java, South America, Asia and the Middle East, and only the economically important species are considered in Russia, Poland, New Zealand and the Philippines. Wilson collected about 45 species, representing about 27 genera, from the Philippines. We still have a world that is but slightly explored for eriophyid mites where they undoubtedly occur in profusion wherever higher plant life exists.

Although early work on Eriophyoidea suggested that all eriophyids were highly host specific, some species are now known to occur on more than one plant species or genus and family. It is not uncommon to observe that one host will harbour two or more unrelated species in which one is a gall former, the other an inquiline or free living form.

Materials and Methods

The collection of Eriophyoidea is not as difficult as it may seem, even when collecting is limited to a rather short growing season as in South Dakota. The best time for collecting overwintering mites is when the buds start to grow in early spring. Many of the mites collected in this study caused discernible injury to their host, such as "witches broom," galls of various shapes, marginal leaf rolling, flower and leaf abnormalities, or erinea (hair patches) on the underside of the leaves. Other types of deformation and injuries that eriophyids are known to cause on the host plants are: leaf blisters, drying of bulbs, rusting and bud blasting. Most eriophyids do not cause noticeable injury to their host and careful examination of the stem, leaves (both surfaces), buds, between leaf sheaths and flowers becomes necessary in the collecting technique. Examination of these parts is accomplished with the aid of a 10X or 20X hand lens in the field, to be followed by a thorough examination under a dissecting microscope in the laboratory.

Preservation Methods

In the course of the study Keifer's method (personal communication) has been used for preserving the mites both dry and in liquid media.

Eriophyid mites are preserved in the following ways:

1. Infested leaves or plant parts are wrapped in paper towel or soft tissue, placed in envelopes and allowed to air dry. Dried mummified specimens taken from such materials make good mounts. This dry material may be stored in ordinary letter envelopes or in insect proof containers and may be fumigated or stored with naphthalene balls to prevent invasion by museum pests.

2. Twigs or leaves that are infested with mites may be preserved in a syrup solution consisting of 50 percent ethyl alcohol, 5 grams sugar, or 5 cc. of karo syrup, 2 grams of iodine crystals. This preservative was used consistently in this study.

Mountant and Mounting Technique

Slide preparations of Eriophyoidea follow the standard mounting procedure of other kinds of mites in that they must be cleared sufficiently to give a high degree of transparency under the phase contrast microscope. They must be expanded to normal shape before mounting on slides with little or no damage to the exoskeleton.

Ordinarily, 2-depression slides, small stender dishes and match sticks equipped with 00 size insect pin are very useful equipment. The match stick with a needle inserted on one tip is used for picking up the mites. Other useful techniques to pick up mites have been devised and described by Del Rosario and Sill (1958) and Hall (1967b).

Keifer's (correspondence) method was followed for the most part during the course of this study. Formulae and suggestions for slide mounting of eriophyids are discussed below.

Preparatory medium:

Sorbitol	½ gram
Karo syrup	½ gram
Chloral hydrate crystals	2 grams
Glycerin	5 drops

Booster medium:

Karo syrup	1 gram
Chloral hydrate crystals	2 grams
Glycerin	5 drops
Water	2 cc.

Reagent hydrochloric acid—4 drops

Wash medium:

Sorbitol	1.0 gram
Chloral hydrate crystals	1.2 grams
Glycerin	5 drops
Potassium iodide	.1 gram
Iodine crystals	.1 gram
Water	2.5 cc.

Final medium:

Gum arabic powder	1/3 gram
Sorbitol powder	1/3 gram
Karo syrup or honey	1/3 gram
Water	1 cc.
Formalin	2 cc.
Chloral hydrate	3 grams
Potassium iodide	.15 grams
Iodine crystals	.25 grams
Glycerin	5 drops

From the wash medium put the mites onto the permanent slide. Work as quickly as reasonably possible in placing the coverslips to prevent water evaporation as that tends to distort the specimens. Cotton fibers may be placed in the center of the droplet on the slide to hold the coverslip up and prevent flattening of the mites. Keifer (personal communication) used Kapok fibers in this way. The use of cotton fibers as props between the coverslips and slide minimized the accidental cutting of the body setae and squashing of internal genitalic structures. However, such preparations do not yield flat specimens for photomicrographic purposes. Cotton fibers between slide and coverslip render the specimens recoverable by soaking the whole slides in water for more than one hour depending on how much time it takes to soften the medium. The coverslip may be taken off carefully by sliding it to the edge of the slide. Unlike larger flatter Acari which naturally assume a dorsoventral position when mounted, eriophyids have to be carefully oriented by moving the coverslip in order to study their anatomy. This final medium thickens in time so that the coverslips can be eventually ringed. Slow evaporation of the water from under a coverslip does not cause the mites to shrivel appreciably, especially after the formaldehyde has had the opportunity to harden the mite bodies. Quite often many mites in a given sample are found to be unsatisfactory for morphological study and it is therefore recommended that several mites be mounted on each slide. The disadvantages, however, of mounting several mites per slide are that:

1. This method precludes a single type specimen.
2. Frequently, two or more species from a single host are mounted on one slide.

Preparation of slide mounts for

photomicrography requires special techniques. For this purpose, the mites should be mounted without cotton fibers, and flattened so that much of the specimen will be in focus. Keifer's solutions (1954) have proved valuable for preparing thin mounts for this purpose. This technique also requires transferring as in the other method. With this technique, mites are heated on hot plate at 200°F for 10-15 minutes. Upon mounting the cleared mites in the final medium (a very small drop) the coverslip may be moved carefully to orient the mites in the position required for study.

Measurements of the Parts

Terminology of morphological structures used in this account are those of Keifer (1952) and his B series and of Wilson and Oldfield (1970). Measurements are indicated as follows:

length—tip of anterior shield to caudal end;

width—the widest point of the body;

legs—each segment; featherclaw and claw;

rostrum—base to tip;

dorsal setae—entire length;

dorsal tubercle—entire length;

distance between dorsal tubercles—from the center of the bases.

Counts of Abdominal Annuli and Location of Setae

Dorsal annuli—all dorsal annuli at dorsal position;

microtubercles—counts based per 10u arc between ventral setae.

Location of setae on annuli—on lateral setae, counts of annuli begin from behind the shield to position of setae (range given if each located on different annuli).

Third ventral setae—annuli from caudal lobe to the point of location.

Type and Paratype Slides

All holotypes are on deposit in the United States National Museum, Washington, D.C. One paratype of each of the new species has been deposited in the South Dakota State University collection, Brookings, South Dakota; the remainder have been retained in the author's personal collection.

Systematic Account of the Eriophyids of South Dakota

Keifer (1964) divided the Eriophyoidea into three families, Eriophyidae, Ryncaphytoptidae, and Phytoptidae. In 1971, Newkirk and Keifer revised the types of *Eriophyes* and *Phytoptus* following the International Code of Zoological Nomenclature, which resulted in the removal of *Phytoptus* from the eriophyid family, Phytoptidae. This change leaves the group with residual setae without a family, therefore, the name Nalepcllidae was established by Newkirk and Keifer to accommodate the members previously placed in Phytoptidae.

The present study reveals 48 species; six are new and herein named. These are placed and discussed under 19 genera in three families.

Key to the Eriophyoidea

1a. Rostrum abruptly bent down near the base and tapering; oral stylet long. Dorsal setae present or absent; when present always pointing forward to some degree. Habits: rust mites or leaf vagrants .... RHYNCAPHYTOPTIDAE Keifer 1961.

1b. Rostrum evenly bent down, oral stylet always short. Dorsal setae present or absent; if present, pointing forward or backwards.. 2a.

2a. One or two anterior shield setae; anterior thanosomal (subdorsal abdominal) seta pair often present. Internal female spermathecal tubes long or short; when short extending anteriorly first from central near genital opening. Habits: bud mites, gall mites, rust mites and grass mites .... NALEPELLIDAE, Newkirk and Keifer 1971.

2b. Two or no shield setae, never with anterior shield seta. Internal spermathecal tubes always short and extending laterally or diagonally to rear from central opening. Never with lateral tibial spur or subdorsal abdominal setae. Habits: bud mites, erineum makers, gall mites, rust mites and leaf and green stem vagrants .... ERIOPHYIDAE Nalepa 1898.

Family: ERIOPHYIDAE Nalepa

Genus *Abacarus* Keifer

Abacarus Keifer, 1944, Bull. Calif. Dep. Agric., 33:28.
Genotype: *Calepitrimerus acalyptus* Keifer, 1939, Bull. Calif. Dep. Agric., 28:490.

The body is more or less elongated. The tergites form three dorsal, longitudinal, wax-bearing ridges. The central ridge is shorter than the lateral ridges usually ending in a dorsal trough or depression. Abdominal tergites are nearly as numerous as the microtuberculated sternites, the microtubercles may be absent dorsally. Female coverflap of the genitalia with one row of longitudinal furrows.

Abacarus is seperated from *Calepitrimerus* by the location of the dorsal tubercles. In *Abacarus* the setiferous shield tubercles are on the rear margin of the shield, but in *Calepitrimerus* the setiferous shield tubercles are ahead of the rear margin of the shield. Both setae are directed caudad.

Abacarus hystrix (Nalepa)
(Grain Rust Mite)
Plate 2; Fig. 1-2; Plate 43; Fig. 1

Callyntrotus hystrix Nalepa, 1904, Denks, Akad. Wiss. Math. Wien. 77:141.
Epitrimerus hystrix (Nalepa). Nalepa, 1929. Marcellia 25:72.
Epitrimerus hystrix (Nalepa). Pepper, 1942. Jour. Econ. Ent. 35:201-204.
Abacarus hystrix (Nalepa). Keifer, 1944, Bull. Calif. Dep. Agric., 33:28-9.
Type locality: Sacramento, California
Type host: *Elymus triticoides*
Relation to host: These mites feed and breed along leaf furrows of grasses. This species is often associated with another eriophyid, *Aculus mckenzie* which is also found on grasses in South Dakota.

A. hystrix is close to *A. oryzae* K. from rice in the Philippines. *A. hystrix* differs from *oryzae* by having an 8-rayed featherclaw while *oryzae* has 9-rayed. Both species have lines of wax along the dorsal abdominal ridges. *A. sporoboli* K. found in dropseed from South Dakota has 6-rayed featherclaw (this species was not found during this study). *A. hystrix* is known to transmit two different viruses of Gramineae. It is the first rust type of mite associated with virus transmission.

South Dakota Collection record:

Host	Location	Date	Collector
Agropyron repens	Brookings	7/4/70	M. L. Briones
Poa pratensis	Lake Oakwood	7/4/70	M. L. Briones
Poa pratensis	Rapid City	7/19/67	J. Smolik

Various other grasses as well as *Medicago sativa* (alfalfa) recorded by White (1966).

Genus *Acarelliptus* Keifer

Acarelliptus Keifer 1940, Bull. Calif. Dep. Agric., 10:166.
Genotype: *Acarelliptus cocciformis* Keifer 1940, Bull. Calif. Dep. Agric., 10:166.

Rostrum small and projecting down. Abdomen and legs with usual setae. Shield broadly subtriangular, flattened; anterior lobe small and short; a short rostrum mantle attached to the underside of the frontal lobe; dorsal tubercles well ahead of rear margin, the setae short and projecting upward. Abdomen with shield forming a subelliptical body and a lateral longitudinal furrow on each side; sternites microtuberculate; caudal segments distinct from anterior segments and projecting obliquely down. Female genital coverflap with longitudinal furrows.

Acarelliptus occidentalis Keifer
Plate 3, Fig. 1-4; Plate 48, Fig. 7

Acarelliptus occidentalis Keifer 1951, Bull. Calif. Dep. Agric. 17:98.
Type locality: Nine miles south of Grass Valley, California.
Type host: *Quercus kellogii* Newh. (native black oak).
Relation to host: Mites are undersurface leaf vagrants. In South Dakota the mites were associated with *E. mackiei* which formed erineum on the oak leaves.

The species is recognized by its deflexed cauda forming in an elliptical figure. It is closely related to *A. cocciformis* K. from chestnut oak. It differs from *A. cocciformis* in having the dorsal setae directed caudad and laterally. Live mites look like small scale crawlers on the host leaves.

The true relationships of *A. occidentalis* to *A. cocciformis* cannot be determined until further biological information becomes available.

South Dakota collection record:

Host	Location	Date	Collector
Quercus sp.	Black Hills	9/11/70	Preacher Smith

Genus *Aculodes* Keifer

Aculodes Keifer, 1966, Calif. Dep. Agric., Eriophyid Studies B21:19. Genotype: *Vasates mckenzie* (Keifer) 1944, Bull. Calif. Dep. Agric., 33:26.

Wormlike mites with short form oral stylet. All usual setae present. Shield elongate-subtriangular, the anterior lobe attenuate-pointed. Dorsal setae directing divergently to rear. Microtubercles bead-like, more or less pointed out extending anteriorly or posteriorly to any extent from margins. Female genitalia bowl shape.

Aculodes dubius (Nalepa)
Plate 4; Fig. 1-2

Phytocoptes dubius Nalepa 1891, Denk. Akad, Wiss. Wien, 58:880
Aculodes dubius (Nalepa), Keifer 1966, Calif. Dep. Agric., Eriophyid Studies B21:19.
Type host: *Poa pratensis*
Relation to host: Mites are leaf vagrants on the upper surface of grass leaves. No damage noted.

The species was separated from *mckenzie* on the basis of microtuberculation, shield pattern, particularly the arched line in front of dorsal tubercles.

South Dakota collection record:

Host	Location	Date	Collector
Bromus enermis	Yankton	5/12/69	M. L. Briones

Aculodes mckenzie (Keifer)
Plate 4; Fig.3-4

Vasates mckenzie Keifer 1944, Bull. Calif. Dep. Agric., 14:26
Aculodes mckenzie (Keifer) 1966, Calif. Dep. Agric., Eriophyid Studies B21:19.
Type locality: Sacramento, California
Type host: *Elymus triticoides*
Relation to host: Mites live in the longitudinal leaf furrows on the upper surface of the leaves.

The species was separated from *A. dubius* and *Eriophyes tulipae* K. mainly on the shield pattern and microtuberculation. Both *tulipae* and *mckenzie* have seven-rayed featherclaws.

South Dakota collection record:

Host	Location	Date	Collector
Agropyron repens	Brookings	7/4/70	M. L. Briones

A. mckenzie was collected along with *A. hystrix*.

Genus *Aculops* Keifer

Aculops Keifer, 1966, Calif. Dep. Agric., Eriophyid Studies B21:9.
Genotype: *Vasates populivagrans* Keifer 1953, Bull. Calif. Dep. Agric., 42:68.

Fusiform mites with short form oral stylet. All regular eriophyid setae present. This genus possesses an anterior shield lobe over the rostrum base, this lobe may be small or of moderate size, acuminate-rounded or terminating in a sharp or spine-like projecting point. Keifer separated this genus from *Aculus* because it lacks the pair of small spines projecting forward from the lower front of the anterior lobe margin. Dorsal shield tubercles usually are subcylindrical, projecting back over the rear margin, directing dorsal setae caudad, usually divergently. Abdominal thanosome on non-gall makers clearly divides laterally into broader tergites and narrower sternites; this distinction is less clear on most gall formers, the deutogynes tending to have clearer dorsoventral distinction. Thanosomal microtubercles round, elliptical, or produced as spinules; either set ahead on ring margins dorsally extending anteriorly from margins, or, as apinules bent either ahead of caudad from ridges. Genitalia not closely appressed to coxae; anterior female apodeme extending forward from base.

Aculops laevigatae (Hassan)
Plate 5, Fig. 1-6; Plate 50, Fig. 2

Phyllocoptes laevigatae Hassan, 1928, Univ. Calif. Publ. Entomol. 4:379.
Vasates laevigatae (Hassan), Keifer, 1952, Bull. Calif. Insect Survey, 2:45.
Aculus vallis Keifer 1966, Ent. Calif. Dep. Agric., Eriophyid Studies B-20:13.
Vasates michineri Hall, 1967, Univ. Kansas Sci.Bull. 47:659.
Aculops laevigatae (Hassan) Keifer, 1966, Calif. Dep. Agric. Eriophyid Studies B-20:13.

Type locality: Agnew, Santa Clara Co., California
Type host: *Salix laevigatae*
Relation to host: *Aculops laevigatae* and *Aculus vallis* form bead galls on the host whereas *Vasates michineri* is found in distorted buds. In South Dakota the mites are found in high populations in bead galls on the underleaf surfaces of the host. (Fig. 1).

The South Dakota species from willows constitute another example of a strongly deuterogenous group. All three species previously described in the United States possess 4-rayed featherclaws and have been separated mainly on the basis of their shield pattern, microtuberculation on the annules and internal genital apodeme. *A. laevigatae* was illustrated and redescribed by Keifer (1939). (Plate 50). His illustration is apparently that of a deutogyne. Keifer (1966) described another species from Salix, *Aculus vallis* (Plate 50; Fig. 1) differentiating it from *A. laevigatae* by its narrow shield lines; *A. laevigatae* has wider shield lines and tergites more numerous and with shorter tibia than *A. vallis*. The following year Hall (1967) described another species from *S. nigra* in Kansas, *Vasates michineri*, stating that *A. laevigatae* and *V. michineri* are similar species; differentiating them only on the basis of the genital apodeme, *V. michineri* being long and narrow. Perhaps both workers disregarded the possibility of variation within the populations; they described and based the species separation on an inadequate number of specimens.

Comparison of the South Dakota materials with Keifer and Hall's species indicates that here again is an example of probably a complex of populations which may or may not eventually be considered as valid species. Morphologically the South Dakota populations represent the *A. laevigatae*, the *V. michineri* and the *A. vallis* types. However, in

FIGURE 1. Bead galls on leaves of *Salix amygdaloides* caused by *Aculops laevigatae* (Hassan).

view of the complex species already noted and present lack of understanding of biological forms of deuterogenous groups in *Salix* hosts, the South Dakota species is listed under *laevigatae* until life histories are studied. Likewise, other subsequent species are listed as possible synonyms. Perhaps the shortness of the internal apodeme of *A. laevigatae* in comparison to *V. michineri* is insignificant and maybe due to mounting procedure or stage of development of the mites, which could produce intermediate forms between the protogyne and deutogyne stages. It seems that the illustration of *A. laevigatae* is a deutogyne. Further discussions of the complex species of mites forming bead galls on *Salix* sp. is given by Keifer (1966).

South Dakota collection Record:

Host	**Location**	**Date**	**Collector**
Salix amygdaloides	Lake Goldsmith	6/5/69	M. L. Briones

Aculops lobuliferus (Keifer)
Plate 6, Fig. 1-7; Plate 44, Fig. 5

Aculus lobuliferus Keifer 1961, Bull. Calif. Dep. Agric., Eriophyid Studies B-3:13.
Aculops lobuliferus Keifer 1966, Bull. Calif. Dep. Agric., Eriophyid Studies B-21:9.
Type host: *Populus* sp.
Relation to host: In South Dakota the mites cause marginal leaf rollings of the young leaves.

Keifer described several species from cottonwood which are morphologically closely related to *A. lobuliferus*. *Aculops populivagrans* (Keifer) was collected from *Populus fremontii* in Sacramento, California in 1953. These mites according to Keifer, are vagrants on both leaf surfaces; their activities perhaps result in some silvering in drier areas. The deutogynes hibernate in twig crevices. In 1961 a new species was described by Keifer from eastern cottonwood (*Populus deltoides*) from Stoneville, Mississippi. This was *Aculops lobuliferus* (Keifer). Keifer separated *A. lobuliferus* from *A. populivagrans* on the basis of shield design as lines of granules. In 1964, another species from a cottonwood from Ogden, Utah was described by Keifer as *Aculops knowltoni* (Keifer). *A. knowltoni* was differentiated from *A. populivagrans* by having a stronger shield design and rounded shield sides. With *A. populivagrans* the lateral shield lobes are somewhat produced according to Keifer. He also noted that *A. populivagrans* from the type locality were leaf vagrants. *A. knowltoni* was also taken from catkin galls attributed to a different species, *Eriophyes neoessigi* (K.); Keifer however, assumed that *E. knowltoni* was an inquilin in these galls. Whether it is a leaf vagrant species or not he was unable to determine in view of the nature of the sample plant specimens brought to him.

It is interesting to note that all these species possess 4-rayed featherclaws and if real morphological differences occurred they were on the intensity or distinctiveness of the shield pattern only.

Examination of the South Dakota species from cottonwood showed that it resembles *A. lobuliferus* on the basis of shield design and general characters, therefore, it is placed under this species.

The slight variations observed among these three "different" closely related species on cottonwood remind us of the population variation in eriophyids which has not been fully understood. Perhaps *A. populivagrans*, *A. lobuliferus* and *A. knowltoni* are conspecific because the species have many taxonomic characters in common with each other. However, a bio-systematic proof in this regard is still lacking. Therefore, their taxonomic status will remain as such until further biological studies are made.

South Dakota collection record:

UHost	Location	Date	Collector
Populus deltoides	Brookings Co.	8/12/69	M. L. Briones

Aculops maximilianae n. sp.
Plate 7, Fig. 1-6; Plate 8; Plate 51

This is the second species in *Aculops* described with 6-rayed featherclaws. *A. verpasi* Keifer from Guatemala (1971, C5:15) features comparatively large spines in its thanosomal tergites and sternites. This species has bead-like and somewhat pointed microtubercles and further differs from *verpasi* on shield pattern and genitalia.

Female 140-170u long, avg. 152u ; 45-50u thick and 50u wide, body wormlike in shape. Rostrum 16-20u long, avg 18.2u , curved down; antapical seta ca. 5u long. Shield 25-30u long, avg 27u ; anterior lobe short and blunt, somewhat rounded on others. Shield design consists of narrow lines hearing granules and short dashes, somewhat variable patterns noted, some depict a network design and some do not; however, the median line is moderately clear in the middle tending to end in a dart shape; admedian lines complete from side center of anterior lobe, curved out slightly to rear margin. First and second submedian lines subparallel to admedian lines, also moderately clear, of dashes and granules arching out posteriorly. Lateral shield with lines or bands or granules. Dorsal tubercles ca. 2u long, 25-29u apart; axis of tubercles transverse with body. Dorsal setae 14-20u long projecting caudad. Forelegs: tarsus 6-6.5u long, tibia 6-8u long, with tibial setae of 5-6u long; patella 4u long, femur 8-10u long with setae 8-10u long. Claw 6u long slightly curved and somewhat prominently knobbed; featherclaw simple ca. 6u long and with 6-rayed. Hindlegs: tarsus 6-6.5u long; tibia 6-6.5u long; patella 4u long; femur 7-9u long with 8-10u long setae. Claw 6-7u long; featherclaw 6u long and 6-rayed. First coxal setae

15-30u long, the tubercles closer to first than third; third coxal setae 35-45u long parallel to cross lines between 3rd tubercles. Coxal sternal line distinct and slightly forked. Coxae with granules and dashes with 5-6 cross lines at base of genitalia. Female genitalia 12-15u long and 20-23u wide with a coarse granule line at base; genital setae 7-10u long; coverflap with 8-10 longitudinal ribbings. Abdominal thanosome with 35-44 tergites and 60-64 sternites; the tergites wider than sternites. Microtubercles bead-like and somewhat pointed and progressively elongates on tergites, situated on rear margin of the annuli. Lateral setae 20u long on 7-11 sternal annuli; VS_1; 40-42u long on 12-16 sternal annuli from VS_2, 40u long on 13-18 sternal annuli from VS_1; VS_3, 18-20u long on 4-5 telosomal annuli from rear. Number of microtubercles per 10u arc between VS_1, 7-8; between VS_2, 7-8; between VS_3, 6-8. Accessory setae 2-3u long.
Male: 140-150u long; genitalia 10-11u long, and 17u wide; genital setae 7u long. About 6-7 irregularly cross lines ahead of genital plate. Anterior sternal line similar to female. Abdominal tergites 25-35 and 54-59 annuli on sternites.

Type locality: Sexauer Park, Brookings, South Dakota
Type host: *Helianthus maximiliana* (Compositae)
Date collected: 7/12/69
Collector: M. L. Briones
Relation to host: Mites are underleaf surface vagrants.
Type materials: A type slide with above date; 10 paratype slides and dried leaves with mites.

Aculops toxicophagus (Ewing)
Plate 9, Fig. 1-3; Plate 44, Fig. 6

Phyllocoptes toxicophagus Ewing, 1917, Proc, Iowa Acad. Sci. 24:323.
Aculops toxicophagus (Ewing), Keifer 1966, Calif. Dep. Agric. Eriophyid Studies B21:9.
Type locality: Western Oregon
Type host: *Rhus* sp.
Relation to host: The mites produce leaf pocket galls on poison oak, especially on the terminal leaves. Galls are hairy inside and are often numerous enough to deform the whole leaf. In South Dakota, the mites produced blister gall damage to their host (Fig. 2).

Keifer (1938) redescribed and illustrated this species from *Rhus diversicola* from California. The species is recognized by the shield shape, pattern and the often strongly microtuberculated tergites.

South Dakota collection records:

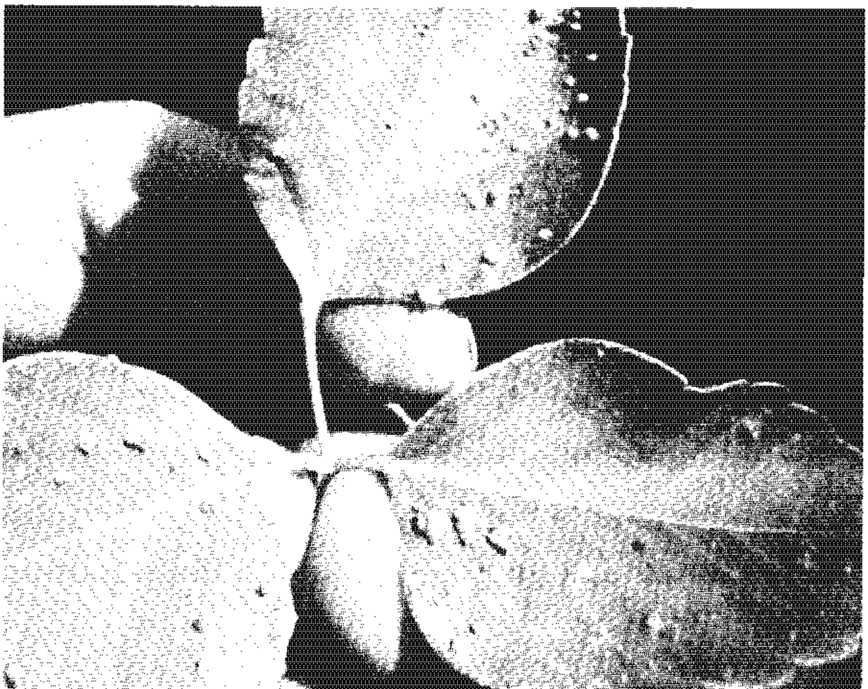
Host	**Location**	**Date**	**Collector**
Rhus radicans	Lake Goldsmith	8/12/69	M. L. Briones

Genus *Aculus* Keifer

Aculus Keifer 1959, Calif. Dep. Agric., Eriophyid Studies 27:5.
Phyllocoptes ligustri Keifer, 1938, Bull. Calif. Dep. Agric., 27:190-191. (This is the protogyne).
Aculus ligustri (Keifer), Keifer, 1959, Calif. Dep. Agric., Eriophyid Studies 27:5-6.

Keifer erected the genus *Aculus* to accommodate certain species that had been lumped under *Vasates*. Species in this genus have the dorsal tubercles reclining over the rear shield margin with their transverse axes parallel to the rear shield margin. These tubercles direct the dorsal setae backward and somewhat outward. Protogynes of this genus have a pair of small spines projecting from the anterior shield lobe sometimes appearing to arise from the underside. Shield is subtriangular, abdomen of protogyne usually with tergites broader and strongly differentiated from sternites. Deutogynes lack the anterior lobe spines, with sternites and tergites less differentiated and microtubercles more or less suppressed. This genus is represented in Europe, Asia and United States.

FIGURE 2. Blister galls on leaves of *Rhus radicans* caused by *Aculops toxicophagus* (K.).



Aculus cornutus (Banks)
Plate 10, Fig. 1-6; Plate 46, Fig.2

Phyllocoptes cornutus Banks, 1905, Proc. Entomol. Soc. Wash., 7:141.
Phyllocoptes cornutus Banks, Keifer, 1938, Bull. Calif. Dep. Agric. 27:306.
Phyllocoptes cornutus Banks, Keifer, 1941, Bull. Calif. Dep. Agric., 30:208.
Vasates cornutus (Banks), Keifer, 1945, Bull. Calif. Dep. Agric. 15:139.
Aculus cornutus (Banks), Keifer, 1966, Calif. Dep. Agric., Eriophyid Studies B21:21-23.
Type locality: Washington, D. C.
Type host: *Prunus persica*
Relation to host: The mites live on either surface of peach leaves.

The protogyne possess a pair of spines just under the frontal shield lobe. This particular character removes this species from the *Vasates* group. The true relationship between *cornutus* and *fockeui* is still not determined. *A. fockeui* is reported a vector of the latent virus of plum. (Proeseler and Kegler, 1966). Both species are morphologically inseparable.

South Dakota collection record:

Host	**Location**	**Date**	**Collector**
Prunus persica	Yankton	7/11/68	M. L. Briones

Only few specimens found at the time of collection.

Aculus nigrus Keifer
Plate 11, Fig. 1-6; Plate 46, Fig. 1

Aculus nigrus Keifer 1959, Calif. Dep. Agric., Eriophyid Studies 28:4.
Type locality: Rock Creek park, Washington, D. C.
Type host: *Juglans nigra* L. (Eastern black walnut)
Relation to host: The mites are vagrants on the underside of the leaves, causing some rusting. In South Dakota, the mite is a vagrant on underleaf surfaces. No apparent damage noted.

This species belong to *Aculus* due to the presence of a pair of small spines on the anterior shield lobe (Plate 11, Fig. 5). These spines are very difficult to locate and the mites must be properly oriented on slide to see them. The most distinguishing feature of this species is the strong diagonal line across the lateral shield lobe and the 4-rayed featherclaw.

South Dakota collection record:

Host	**Location**	**Date**	**Collector**
Juglans nigra	Brookings	9/12/69	M. L. Briones

Aculus schlectendali (Nalepa)
Plate 12, Fig. 1-6; Plate 46, Fig. 3

Phyllocoptes schlectendali (Nalepa), Nalepa 1890, S. B. Adad. Wien, 99:62.
Vasates malivagrans (Keifer), Keifer 1946, Bull. Calif. Dep. Agric., Eriophyid Studies 16:41.
Aculus schlectendali (Nalepa), Keifer 1966, Bull. Calif. Dep. Agric., Eriophyid Studies B21:21.
Type locality: Vine Hill, Santa Cruz Co., California
Type host: *Pyrus malus*
Relation to host: The mites occur in the underside of the leaves. In South Dakota the mites were collected under the leaf surface of the host. No discernible injury that could be attributed to this mite.

A. schlectendali is one of those species lumped under the genus *Vasates* or *Phyllocoptes* by previous workers. Because it possesses a pair of small spines on the anterior lobe, (Plate 12, Fig. 3), it is placed under *Aculus*.

South Dakota collection record:

Host	Location	Date	Collector
Pyrus sp.	Brookings	7/9/70	M. L. Briones

Genus *Anthocoptes* Nalepa
Anthocoptes Nalepa 1892, Anz. Akad. Wien, 29:16.
Genotype: *Anthocoptes loricatus* Keifer, 1938, Bull. Calif. Dep. Agric., Eriophyid Studies 11:312 (By subsequent designation).

The genus may be characterized by the distinct or large annulated tergites covering many sternites each. These tergites are more or less evenly arched. Dorsal setae project backward. Caudal portion suddenly with smaller annular rings. The genus is easily separated from *Heterotergum* on the basis of the first 3 to 5 tergal annuli. All the *Anthocoptes* tergal annuli are much enlarged whereas in *Heterotergum*, the first 3 to 5 tergal annuli are much reduced.

Anthocoptes bakeri Keifer
Plate 36, Fig. 6; Plate 47, Fig. 1

Anthocoptes bakeri Keifer 1959, Bull. Calif. Dep. Agric., Eriophyid Studies 28:2-3.
Type locality: University of Maryland Campus, College Park Maryland.
Type host: *Gleditsia triacanthos* L. (Leguminaceae), honey locust.
Relation to host: Rust mites on the underside of the leaves. In South Dakota the mites were found living on the undersurface along the

midribs and bases of the leaves; the area where the mites fed and bred appeared rusted.

This genus is not very well known, there are only fonr species reported in North America. These all possess a 5-rayed featherclaw. *A. bakeri* is characterized by the broadly rounded large tergites.

South Dakota collection records:
These mites were collected along with *Vasates gleditsiae*.

Host	Location	Date	Collector
Gleditsia triacanthos	Gayville	6/24/69	M. L. Briones
	Brookings	7/24/70	M. L. Briones

Anthocoptes punctidorsa Keifer
Plate 1, Fig. 1-5; Plate 47, Fig. 2

Anthocoptes punctidorsa Keifer, 1943, Bull. Calif. Dep. Agric., Eriophyid Studies 13:216.
Type locality: Sacramento, California
Type host: *Ulmus pumila*
Relation to host: Mites are undersurface leaf vagrants. In South Dakota the mites were collected along the base of midrib on the underleaf surface. At the time of collection only a few mites were found.

This species, according to Keifer, has some females with less accentuated tergal structure which approach that of the male. The male has very much reduced tergal structure. It is interesting to note that in Keifer's illustration of the species there is this variation of tergal structure in some females which does not depict a typical female *Anthocoptes* with the broad tergal enlargement. The South Dakota species generally fit with the less accentuated tergal enlargement mentioned by Keifer. There are only six specimens collected from South Dakota, and the typical *Anthocoptes* character with broad tergal rings was not noted. However, there is a male in the collection which has much less accentuated tergites (Plate 1, Fig. 4-5). Here again is the indication of variation of species characters that is not well understood in the present taxonomic status of eriophyid mites and only after its biological study is made would evaluation be more meaningful.

South Dakota collection record:

Host	Location	Date	Collector
Ulmus sp.	Brookings	7/12/70	M. L. Briones

Genus *Calepitrimerus* Keifer

Calepitrimerus Keifer, 1938, Bull. Calif. Dep. Agric., 26:310.
Genotype: *Calepitrimerus cariniferus* Keifer, 1938, Bull. Calif. Dep. Agric., 26:310.

This genus is characterized by the short rostrum, directed ventrad. Shield is projected anteriorly over the rostrum base. Body somewhat flattened dorsoventrally, elongate wedge-shaped in dorsal view. Accessory setae present. Principal part of the abdominal dorsum longitudinally concave, flanked laterally by a ridge on each side that begins a short distance behind the shield, terminating shortly before the anal lobes; mid-dorsal anterior half or ⅔ of abdomen, consist of a large sharp ridge, ending abruptly to the rear.

Calepitrimerus baileyi Keifer
Plate 28, Fig. 3-6; Plate 48, Fig. 2

Calepitrimerus baileyi Keifer 1938, Bull. Calif. Dep. Agric., Eriophyid Studies 2:310. (Description of the protogyne)
Phyllocoptes aphrastus Keifer 1940, Bull. Calif. Dep. Agric., Eriophyid Studies 12:122. (Description of deutogyne)
Type locality: Davis, California
Type Host: *Pyrus malus*
This species is characterized by the wedge-shaped body which is widest across the shield.
Relation to host: The mites live on the underside of the leaves among the hairs, causing slight browning to the leaf surface. The deutogynes hibernate around the buds just back of the terminal bud. In South Dakota this same relationship with the host is observed.

South Dakota collection record:

Host	Location	Date	Collector
Pyrus malus	Brookings	7/26/70	M. L. Briones

Calepitrimerus vitis (Nalepa)
(Grape rust mite)
Plate 28, Fig. 1-2

Epitrimerus vitis Nalepa 1905, Anz. Akad. Wiss. Wien, 42:445.
Phyllocoptes vitis Nalepa 1905, Anz. Akad. Wiss. Wien, 42:268.
(This is a reference to the deutogyne, noted by Keifer).
Type locality: Austria
Type host: *Vitis vinifera*
This species has the mid-dorsal ridge on more than ⅔ of the abdomen.
Relation to host: The mites live on the underside of the leaves. In California, according to Keifer (1952), the species is strongly deuterogynous. In South Dakota, the mites were found on wild grape on the underleaf surface. The leaves showed rusting symptoms.

South Dakota collection record:

Host	Location	Date	Collector
Vitis riparia	White	8/12/69	M. L. Briones

Genus *Cecidophyes* Nalepa

Cecidophyes Nalepa 1889. Sb Akad. Wiss. Math-Natur. Wien, 98:31. Genotype: *Phytoptus galii* Karpelles 1884, in Keifer, 1938. Bull. Calif. Dep. Agric., 26:302. (By subsequent designation.) *Cecidophyes galii* Nalepa, 1889, SB, Akad. Wien, 98:142.

The mites of this genus lack setiferous dorsal tubercles on the shield; female genitalia appressed to the spread rear coxae, genital female coverflap longitudinally furrowed, anterior female apodeme much shortened in ventral view.

Cecidophyes collegiatus Keifer
Plate 13, Fig. 3, 6, 9; Plate 43, Fig. 2

Cecidophyes collegiatus Keifer, 1961. Bull. Calif. Dep. Agric., Eriophyid Studies B3:11.
Type locality: College Park, Maryland
Type host: *Acer platanoides*
Relation to host: Mites are undersurface leaf vagrants. No injury to the leaves noted.

South Dakota collection record:

Host	Location	Date	Collector
Acer platanoides	Yankton	5/24/68	M. L. Briones
	Brookings	5/5/69	M. L. Briones

Cecidophyes pusilla Keifer
Plate 13, Fig. 1, 2, 4, 5, 7, 8; Plate 43, Fig. 5

Cecidophyes pusilla Keifer, 1962. Bull. Calif. Dep. Agric., Eriophyid Studies B5:2-3.
Type locality: College Park , Maryland
Type host: *Quercus falcata*
Relation to host: The mites are undersurface leaf vagrants, along the midrib. In South Dakota this species occurs with *E. mackiei* and *A. occidentalis*.

A *Heterotergum* sp. was noted in this same collection. Determination of this particular species is being held in view of the few materials now on hand.

South Dakota collection record:

Host	Location	Date	Collector
Quercus macrocarpa	Gary Co.	9/6/67	B. McDaniel

Genus *Eriophyes* Von Siebold

Eriophyes Von Siebold, 1951 Jahresh. Schles. Ges. 28:29.
Type of genus[1]: *Eriophyes labiatiflorae* Thomas.
(Designation by monotopy) 1872, Zeifchr. Fur Gesam Naturwis. n.s. 29:459.

Members of this genus have the following characters: Wormlike body with thanosomal rings subequal dorsoventrally. Rostrum of moderate size, with short form oral stylet. Two dorsal shield setae, arising from dorsal tubercles situated on rear shield and direct the setae caudad, usually divergently. Legs with all standard setae including foretibial setae; forecoxae separated by sternal line. All coxal setae present.

Eriophyes arceosae n. sp.
Plate 14, Fig. 1-6

This species is morphologically different from the other described *Eriophyes* with 4- or 5-rayed featherclaws on the bases on more than four combined attributes. It is found related to *E. paradianthi* only on the shape of the shield and cell-formed shield pattern. It differs in shapes of microtubercles and genitalia, sternal and coxal ornamentation. *E. paradianthi* has 6-rayed featherclaw and the shape of internal female apodeme is different. While the relationships to other *Eriophyes* has been made only on their morphological characters and biological relationships are still missing, the South Dakota species is described as new.

Female 110-130u long, average 125u, wormlike. Rostrum 15-21u long, projecting diagonally down; antapical seta 5-6u long. Shield 25-28u long, the anterior lobe somewhat rounded. Shield design of distinct lines: median line clear, meeting cross lines at rear ⅓, another at about ⅔, and a clear dart shaped mark at rear margin; admedian lines complete from side center meeting near the anterior lobe, gently arched out at middle and back to cross line at about ⅔; from there arching out still farther back to near rear margin. First submedian lines from sides of anterior lobe subparallel to admedian ending at first cross line from rear margin. Lateral shield from submedian line with about 7 cells formed by the subsequent submedian lines ahead of the dorsal tubercles. First cross line extending ahead of dorsal tubercles. Shield laterally with a band of granules above coxae. Dorsal tubercles 2u long, transverse to body, 18-20u apart; dorsal seta 20-23u long, located slightly ahead of rear of shield margin, and pointing caudad, slightly diverging. Foreleg: Femur 6-7u long, with 4-5u long seta; patella 4-5u

[1]Keifer in 1938 designated Eriophyes vitis (Pgst.) (By subsequent designation) as the genotype. Reference as to the revision of Eriophyes and Phytoptus see Newkirk and Keifer, 1971. USDA, ARS Eriophyid Studies C5.

long; tibia length 5u with 5-6u long seta; tarsus 4-5u long; claw 7-8u long; featherclaw 7u long with 6-rays. Hindleg: Femur 6-7u long with 4-5u long seta; patella 4-5u long; tibia 5u long; tarsus 4-5u long; claw length 7-8u; featherclaw 6-7u long with 6-rays. Coxae ornamented with sparse curved lines and more granules; anterior coxae moderately connate with narrow sternal line; first setiferous coxal tubercles farther apart than second and behind anterior coxal approximation; first coxal seta 6-7u long; second tubercles only a short distance of the line across third coxal tubercles, with 20-30u long seta; third coxal setae 30-40u long. Abdominal annuli equal on tergites and sternites with 60-69 annules. Lateral seta 20-25u long located on 10-11 annuli from rear margin. VS_1, 35-40u long on 13-17 annules from Ls: VS_2, 6-7u long on 15-17 annuli from VS_1; VS_3, 20-22u long on 22-24 annuli from VS_2, or 4-5 annuli from the caudal lobe. Accessory seta 5u long. Abdominal microtubercles rounded on ring margins, tending to be larger towards the ventral telosome and progressively becoming lines to rear. Female genitalia 11-12u long, 19-20u wide with 18-20u long seta; genital coverflap with 10-12 longitudinal lines or ribs.

The species is named after R. A. Arceo.

Type host: *Caragana arborescens*
Type locality: Brookings, South Dakota
Date collected: 7/24/70
Collector: M. L. Briones
Relation to host: The mites are found on the leaf axils and buds, causing severe drying of the buds.

Type materials:
A type slide with above date; 10 paratype slides; dried and alcohol preserved mites in buds.

Eriophyes chondriphora (Keifer)
Plate 17, Fig. 1-8; Plate 45, Fig. 1

Aceria chondriphora Keifer, 1965, Bull. Calif. Dep. Agric., Eriophyid Studies B13:5-6.
Eriophses chondriphora (Keifer) Newkirk and Keifer, 1971, USDA, ARS Eriophyid Studies C-5.
Type locality: Allen Spring, Lake Co., California
Type host: *Fraxinus latifolia* Benth. (Oleaceae), Oregon Ash
Relation to host: These mites produce masses of bead galls on the leaves with most of the openings on the lower surface. In South Dakota two types of damage were noted, bead galls on the leaves (Fig. 3) and fruiting bodies formed as pendant masses of tissues, (Fig. 4). *Eriophyes nimia* (Hall), is the mite responsible for the pendant masses of tissues in *F. americana* in Kansas. This abnormality is similar to the fruiting bodies formed as pendant masses of tissues found in *F. pennsylvanica* in South Dakota.

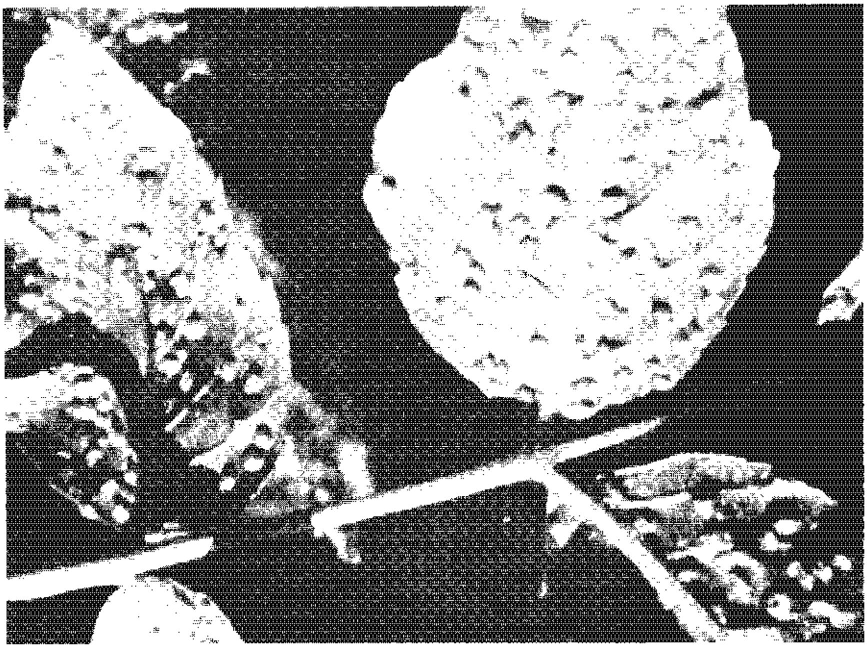


FIGURE 3. Blister bead galls on *Fraxinus pennsylvanica* caused by *Eriophyes chondriphora* (K.).

FIGURE 4. Pendant masses of tissues caused by *Eriophyes chondriphora* (K.) on *Fraxinus pennsylvanica*.

There appears to be two types of females from the South Dakota *F. pennsylvanica*; both types have 4-rayed featherclaws, and were collected from both leaf galls and fruiting bodies. One type of female resembles *E. chondriphora* in shape, shield markings and microtuberculations, but other females in the South Dakota populations have longitudinal lines on the genital coverflap, thereby differing from *E. chondriphora* which has an un-lined genital coverflap and possesses 3-rayed featherclaws. The male of this type has similar shield markings, microtuberculations but has 4-rayed featherclaws. The other type of female is similar to *E. nimia*. (described by Hall in 1967 from Kansas) in shape of microtubercles, genital coverflap and number of featherclaws; differing only in the shield pattern. South Dakota populations have definite shield markings while *E. nimia* has an unmarked shield. In the South Dakota samples, a female was noted with a nymph inside the body (Plate 17, Fig. 7), indicating an ovoviviparous type of reproduction. It was further observed that a majority of the females collected from the leaf bead galls in South Dakota were strongly deuterogenous with 3-rayed featherclaws, smooth shield markings and smooth genital coverflap. Deutogynes normally do not have microtubercles. In view of the complete lack of biological studies of this particular species, the South Dakota species are placed under *E. chondriphora* until more information regarding the life histories of this species become available. It must also be noted that no studies have been made on the morphology of the offspring of the ovoviviparous protogyne females. Morphological variation within a species has not been given enough consideration in eriophyids but it obviously exists, so that the description of new species on the basis of one or two morphological differences does not truly contribute to progress in the work on this particular group. Perhaps a different approach to study eriophyid taxonomy is needed now to accommodate the variability in a population complex.

The inadequate descriptions and illustrations of Nalepa's *E. fraxinovorous* and subspecies further complicates the comparison of the South Dakota species with Nalepa's species.

South Dakota collection record:

Host	Location	Date	Collector
Fraxinus pennsylvanica	Mitchell	6/5/69	B. H. Kantack
F. pennsylvanica	Brookings	7/23/69	M. L. Briones

Eriophyes calaceris (Keifer)
Plate 29, Fig. 5-6; Plate 43, Fig. 5

Aceria calaceris Keifer, 1952. Bull. Calif. Dep. Agric., 41:33.
Eriophyes calaceris (Keifer), Newkirk and Keifer 1971, Eriophyid Studies C5.
Type locality: El Dorado Co., California
Type host: *Acer glabrum* Torr. (Sierra Maple)

Eriophyes celtis Kendall
Plate 15, Fig. 1-6; Plate 45, Fig. 4

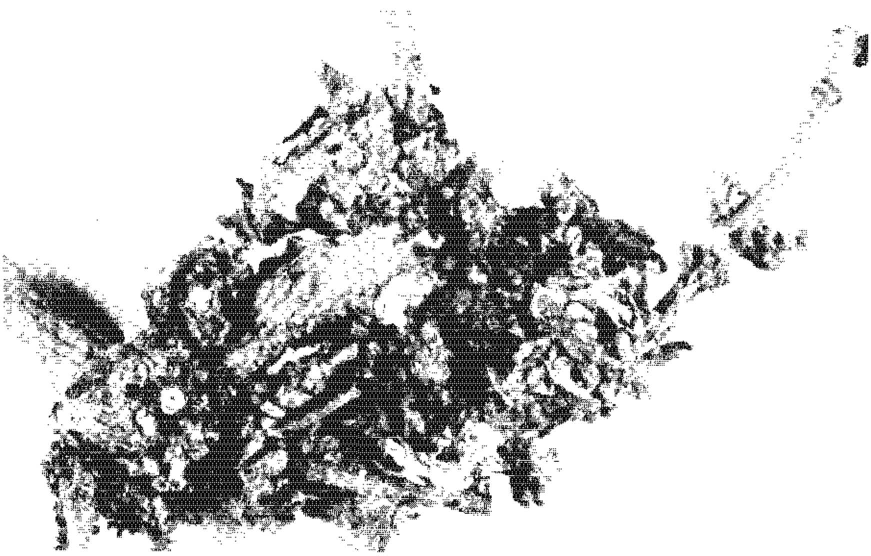
Eriophyes celtis Kendall, 1929. Psyche 36:300.
Type locality: Forest Hills, Massachusetts
Type host: *Celtis occidentalis canina*
Aceria snetsingeri Keifer, 1957. Bull. Calif. Dep. Agric., 46:244.
Relation to host: The mites cause bud deformation and "witches broom". Kendall (1929) and Keifer (1957) described the same type of damage found in South Dakota. (Fig. 6). Hall (1967b) mentioned similar damage from Kansas, Oklahoma and Texas on *Celtis occidentalis*. It is apparent this species is widespread.

South Dakota hackberry probably exhibits two morphologically different species of *E. celtis*. One is of the *snetsingeri* type and the other differs from *celtis* on the basis of the genital coverflap and length of the mites. Specimens in the species of *celtis* have smooth genital coverflaps while the other species noted in South Dakota possesses a genital coverflap with longitudinal lines. With the present inadequate knowledge regarding the complex of eriophyids on *celtis*, the South Dakota species is placed under *E. celtis* until the biology of the species from hackberry is studied.

South Dakota collection record:

Host	Location	Date	Collection
Celtis occidentalis L.	Lake Oakwood	7/12/69	M. L. Briones

FIGURE 6. Bud proliferations on *Celtis occidentalis* caused by *Eriophyes celtis* Kendall.



Eriophyes celtis Kendall
Plate 15, Fig. 1-6; Plate 45, Fig. 4

Eriophyes celtis Kendall, 1929. Psyche 36:300.
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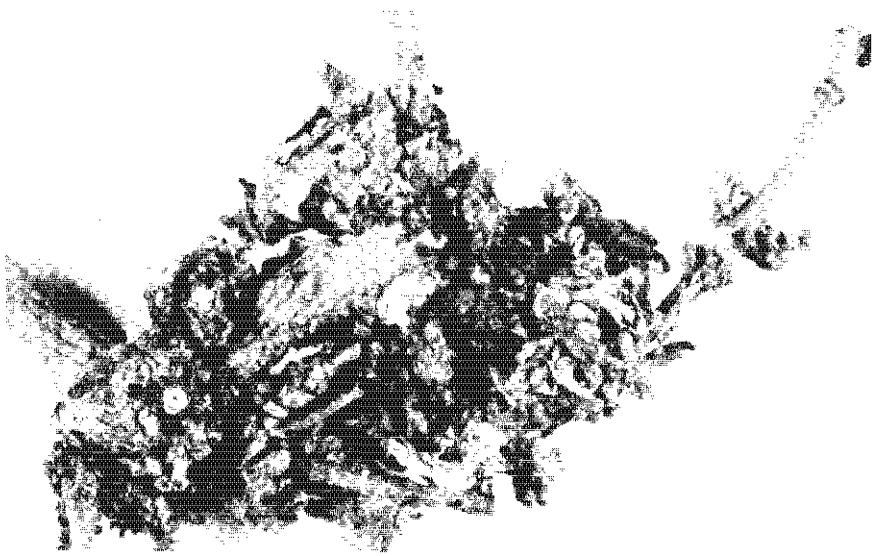
South Dakota collection record:

Host	Location	Date	Collection
Celtis occidentalis L.	Lake Oakwood	7/12/69	M. L. Briones

FIGURE 6. Bud proliferations on *Celtis occidentalis* caused by *Eriophyes celtis* Kendall.



Eriophyes douglasiana (Wilson and Oldfield)
Plate 16; Fig. 1-6

Aceria douglasiana Wilson and Oldfield, 1966, Ann. Entomol. Soc. Am. 59:589.
Type locality: Woodchuck Park, 9 miles east of Temucula, Riverside Co., California.
Type host: *Artemisia douglasiana*
Relation to host: Mites were found among the hairs on the undersurface of leaves with no damage noted. In South Dakota, the mites were collected from the undersurface of the leaves of *Solidago* sp. and *Cerastium arvense* among the hairs. No damage was noted on both hosts.

South Dakota collection record:

Host	**Location**	**Date**	**Collector**
Cerastium arvense	Lake Goldsmith	6/5/69	M. L. Briones
Solidago sp.	White	8/12/69	M. L. Briones

Eriophyes mackiei (Keifer)
Plate 20, Fig. 1-4; Plate 4 5, Fig. 2

Aceria mackiei Keifer, 1938, Bull. Calif. Dep. Agric., Eriophyid Studies 2:302.
Eriophyes mackiei (Keifer) Newkirk and Keifer, 1971. Eriophyid Studies C5.
Type locality: Capitol Park, Sacramento, California
Type host: *Quecus chrysolepsis* Liebm.
Relation to host: In South Dakota the mites formed erineum pockets on the undersurface of oak leaves. (Fig. 7 -8).

The South Dakota species belongs to a complex with 3-rayed featherclaws found on oak and described by Keifer under 4 different species. These are compared in Table 1. Keifer separated *E. paramackiei* from *E. mackiei* mainly by the type of host damage, prominence of shield lines and coverflap structure. *E. triplacis* differs from *E. ecantyx* by having rounded microtubercles and also damage on the host. The South Dakota species is placed in *E. mackiei* on the basis of priority of description rather than any specific characters, since all of them share common gross morphological characters that are not adequate to represent new species.

Careful examination of many individuals within a population revealed many variations such as prominence of shield lines, genital coverflap, tuberculations or markings, and shape of microtubercles. In all the specimens examined, the number of featherclaw rays was consistently 3.

At the present stage of knowledge regarding variation within a population of eriophyoid taxonomy, it is not possible to clearly understand the relationships among the species compared in Table 1, and maybe only biological work will eventually clarify this situation. Perhaps the species found on different varieties of *Quercus* will be found to be conspecific on the basis of further morphological and biological studies.

South Dakota collection record:

Host	**Location**	**Date**	**Collector**
Quercus macrocarpa	White	7/25/69	M. L. Briones

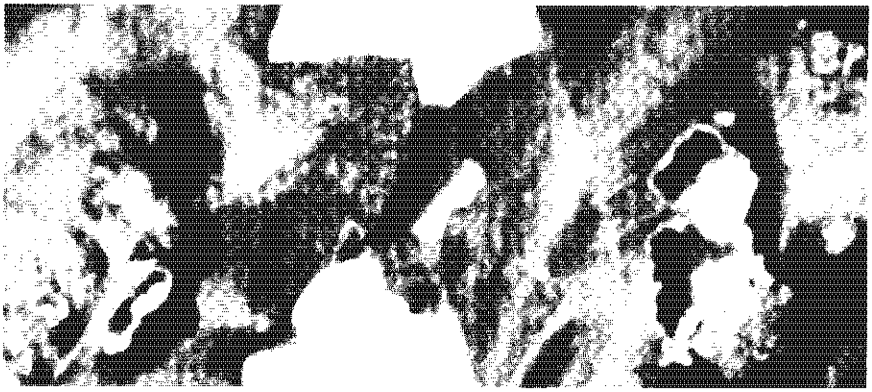


FIGURE 7. Upper leaf surface bulge on *Quercus macrocarpa* as a result of the undersurface erinea pouch caused by *Eriophyes mackiei* (K.).

FIGURE 8. Erinea inside pouch on the underleaf surface of *Quercus macrocarpa* caused by *Eriophyes mackiei* (K.).

Table 1.—Comparison of the *Eriophyes* species with 3-rayed featherclaws found on oak.

Character	*E. paramackiei* (K.) Eriophyid Studies 11:312 1940	*E. mackiei* (K.) Eriophyid Studies 2:302. 1938	*E. ecanthyx* (K.) Eriophyid Studies C2:2. 1969	*E. triplacis* (K.) Eriophyid Studies B1:8. 1960	South Dakota specimens
Female length	150-230u	Up to 23u	160-2[illegible]0u	140-180u	190-205
No. of featherclaws	3	3	3	3	3
No. of abdominal rings	60-65	56-55	52	55-60	63-69
Microtubercles	rounded	rounded	somewhat pointed	some rounded & some somewhat pointed	rounded
Length of LS on abdominal rings	24u on 6-7	20u on 5	21u on 5	23u on 5	20-28 on 5-6
First abdominal	36 on 19	17 on 16	31 on 17	35 on 16	26-35 on 16-19
VS^2 on abdominal rings	12u on 33	11u on 29	7u on 33	8u on 29	9-12 on 29-35
VS^3 on abdominal rings from rear	36u on 4	20u on 4	19u on 5	22u on 5	20-39 on 4-5
Genitalia: Width x length	18x10	20x13	20x12	18x10	17-20x 8-10
Seta length	7.5u	5.5u	7.5u	4.5u	5-7u
No. of lines	8-10	8	10	9-10	8-10
Relation to host	produced clusters of twigs	erineum pockets	on buds	erineum & vagrants on leaves & twigs	erineum

Eriophyes mori Keifer
Plate 18, Fig. 1-6; Plate 43, Fig. 6

Eriophyes mori Keifer, 1939, Bull. Calif. Dep. Agric., Eriophyid Studies
Type locality: Sacramento, California
Type host: *Morus* sp. Mulberry
Relation to host: Mites were collected from the bases and buds of the host. In South Dakota, the mites were found as leaf vagrants on the undersurface of leaves along with *Mesolox tuttlei*.

Mites in this species are characterized by their obscure shield patterns, granular sides and possession of a 5-rayed featherclaws. The abdomen is completely microtuberlated. The South Dakota specimens differs slightly from *E. mori* on the basis of the granulated coxae. The difference is considered insignificant at this stage of the knowledge on the different variations being observed in eriophoid species.

South Dakota collection record:

Host	Location	Date	Collector
Morus alba	Gayville	8/24/70	M. L. Briones

Eriophyes neoartemisiae (Keifer)
Plate 19, Fig. 1-2, 7-8; Plate 44, Fig. 1

Eriophyes neoartemisia Keifer, 1938. Bull. Calif. Dep. Agric., Eriophyid Studies 27:302-3.
Type host: *Artemisia heterophylla* Nutt.
Type locality: Sacramento, California
Aceria neoartemisiae (Keifer), Newkirk and Keifer, 1971, Eriophyid Studies C5.
Relation to host: These mites were vagrants on the undersides of leaves or on the surface of buds. Later, hosts were examined which had numerons crineum pockets developing on the underside of leaves. In South Dakota, the mites caused distortion of general growth, producing clustering of leaves and flowers (Fig. 9).

According to Keifer's observation, some of the larger female mites possessed microtuberculated tergites over the entire dorsum, with their genitalia apparently lacking the large setal lobes, hut had the anterior apodeme as figured for *E. neoartemisiae*. He postulated that this may indicate dimorphism arising from a prior vagrant existence in which the mites later moved into a protected state. This species is very similar to *Eriophyes artemisiae* (Can.) of Europe in shield pattern and Keifer thinks that it may eventually be considered a variety, although the damage of European *E. artemisiae* to the host is not the same as on the California host plant.

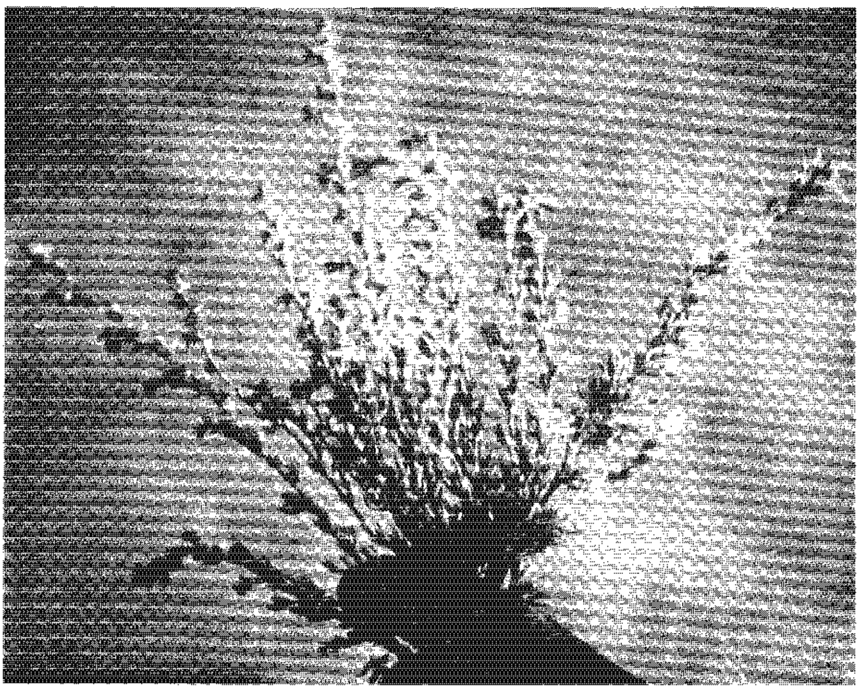
The true relationships that exist between the European, California, and South Dakota *Eriophyes* on *Artemisia* are not presently determined. This is not the first case of a suspected complex status of eriophyids, closely related, and similar in many morphological aspects, which are found in host plants belonging to the same plant genus or families. Many of these situations involving complex mites are found in the South Dakota species and will probably remain as such until the biology of these groups is studied.

South Dakota collection record:

Host	Location	Date	Collector
Artemisia frigida	Lake Goldsmith	6/5/69	M. L. Briones

FIGURE 9. Clustered leaves and flowers caused by *Eriophyes neoartemisiae* (K.) on *Artemisia frigida*.

FIGURE 10. Healthy *Artemisia frigida*.



Eriophyes parapopuli (Keifer)
Plate 19, Fig. 3-4, 5-6; Plate 44, Fig. 2

Eriophyes parapopuli Keifer 1940. Bull. Calif. Dep. Agric., Eriophyid Studies 8:22.
Type locality: Ennis, Montana
Date collected: January 2, 1939
Host: *Populus* sp.
Relation to host: The mites cause a proliferation around the buds, forming irregular woody galls sometimes a half inch or more in diameter. In South Dakota, the same type of damage was noted (Fig. 11.

According to Keifer (1940) *Eriophyes parapopuli* is very similar to Nalepa's *E. populi*, differing only in the pattern of shield and the possessions of accessory setae. It is retained under *E. parapopuli* as the South Dakota specimens fit well with Keifer's description.

South Dakota collection record:

Host	**Location**	**Date**	**Collector**
Populus sp.	Black Hills	7/?/68	L. Wood

Eriophyes parulmi (Keifer)
Plate 21, Fig. 3-4; Plate 44, Fig. 3

Eriophyes parulmi Keifer, 1965, Bull. Calif. Dep. Agric., Eriophyid Studies B-13:9.
Type locality: Beloit, Wisconsin
Type host: *Ulmus, americana*
Aceria parulmi (Keifer), Hall, 1967. Univ. Kansas Sci. Bull. 47:627
Relation to host: Finger-like galls are produced on the upper leaf surfaces. The same galls are found in South Dakota (Fig. 12 and 13). Galls on young leaves are of the same color as the leaves, but brownish or darker on older leaves. According to Hall the infestation in Kansas is localized on the host, with only a few leaves in any single area showing galls. This observation is also true in South Dakota.
South Dakota collection record:

Host	**Location**	**Date**	**Collector**
Ulmus americana	Brookings Co.	8/3/69	M. L. Briones
	Yankton Co.	8/13/69	M. L. Briones

Eriophyes tulipae Keifer
(Wheat curl mite)
Plate 23, Fig. 1-4; Plate 44, Fig. 4

Eriophyes tulipae Keifer, 1938, Bull. Calif. Dep. Agric., 27:185.
Aceria tulipae (Keifer), Keifer, 1952. Bull. Calif. Insect Survey, 2:33.
Aceria tulipae (Keifer), Keifer, 1953. Bull. Calif. Dep. Agric., 42:65.

Aceria sp. Slykhuis, 1953. Can. Jour. Agric., Sci., 33:195.
Eriophyes tulipae (Keifer), Newkirk and Keifer 1971, Eriophyid Studies C-5.
Type locality: Sacramento, Sacramento Co., California.
Type host: *Tulipa* sp.
Relation to hosts: Mites are found along the wheat leaf furrows on the upper surface and cause longitudinal leaf rolling in heavily infested wheat and corn. In wheat the mites move to the heads in response to the maturing of the leaves. In corn, the mites are found on the leaves, stalks, husks, silks, and on kernels.

This species is one of the most economically important eriophyids since it transmits several viruses of wheat, corn and also causes kernel red streak of corn, a toxemia.

E. tulipae is worldwide in distribution, occurring throughout the wheat growing areas of North America and Europe.

South Dakota collection record:

Host	Location	Date	Collector
Agropyron triticum	Western part of South Dakota	8/?/69	W. Gardner

Refer to White (1966) for these host records in South Dakota.

FIGURE 11. Woody proliferation around buds on *Populus* sp. caused by *Eriophyes parapopuli* (K.).

FIGURES 12-13. Leaf galls on *Ulmus americana* caused by *Eriophyes parulmi* and/or *Eriophyes ulmi* (Garman).

Eriophyes taylori n. sp.
Plate 22, Fig. 1-9

This species is close to *E. chondriphora* (Keifer) but differs in the following features: pattern of shield granulations; number of featherclaws, shape of female genitalia; coxal sternal line and ornamentation, and shape of the internal genital apodeme.

Female. Length 120-160u; body thickness 47-50u, width 60-80u. Rostrum 27-30u long; antapical seta 2-3u long. Shield 23-30u long, designed with granulated lines; median line complete on rear ⅓ to first cross line; admedian lines complete; slightly diverging at middle to first cross line, then curved out farther to rear shield margin, enclosing the median line. First submedian line may be faint on some specimens, the second submedian subparallel the first, and forming two irregular cells ahead of the dorsal tubercles. This formation of irregular cells may be faint on some of the specimens. Still with the others, the general pattern of shield design is obscure, except the rear ⅓ of the shield. Dorsal tubercles 3-4.5u long, located on the rear shield margin, 25-30u long and pointing caudally; distance between dorsal tubercles 22-29u; axis of dorsal tubercles transverse to body.

Forelegs: Femur 9-10u long, seta 10-11u long; patella 4u long; tibia 7-7.5u long, seta 6-7u long; tarsus 6u long; claw 6.5-7u long; featherclaw 6-8u long, 4-rayed. Hind legs: Femur 9-10u long, seta 9-10u long; patella 3.5-4u long; tibia 6-7u long; tarsus 5.5-6u long; claw 6.5-7u long; featherclaw 5-8u long, 4-rayed.

Coxae ornamented with distinct granules, sternal line forked anteriorly; first coxal tubercle slightly farther apart than second, first coxal tubercle located on the middle of coxal approximation, seta 10-11u long; second coxal tubercles located on rear of coxal approximation, seta 14-25u long; third coxal tubercle located slightly ahead of the rear mark of coxal approximation; setae 35-45u long. Abdominal annuli entirely microtuberculated, these microtubercles variable, some are definitely pointed others are bead-shaped, somewhat produced dorsally or rear edge of annuli, ventrally they are not touching the rings except in the caudal portion. Total number of abdominal tergites 43-50. LS, 28u long on 9-11 annuli from rear. Counts of microtubercles per 10u are between VS_1, 6-7; between VS_2, 6-8 and between VS_3, 7-8. Accessory seta 3.5-4.0u long. Genitalia, 13-16u long, 20-22u wide, seta 10-13u long; coverflap with 10-11 longitudinal lines.

Male. Males are similar to female except they are generally slightly smaller, averaging 130u long. Genitalia, 11u long, 20u wide, seta 10u long. Number of annuli between genitalia and hind coxae, 6-7.

The species is named after Mr. Charles Taylor, Plant Taxonomist, South Dakota State University, who identified all the hosts used in this study.

Type locality: Brookings, South Dakota
Type host: *Syringa persicae*
Date collected: 6/18/69
Relation to host: Mites collected on the undersurface of the leaves; stern and in the buds.
Other host: *Syringa* sp.

Eriophyes ulmi (Garman)
Plate 21, Fig. 1-2

Phytoptus ulmi Garman, 1883, Ill. State Entom. Rep. 12:187.
Type host: *Ulmus americana* L.
Type locality: Illinois
Relation to host: The mites caused galls on leaves of elm. The South Dakota species was collected on elm galls, (Fig. 12-13), along with *Eriophyes parulmi* discussed on page 44. in this manuscript.

According to Garman the mites are slender with 67 to 70 stria, with 3-rayed featherclaws. This species differs from *E. parulmi* by having 3-rayed featherclaws instead of 5-rayed.

Analysis of the relationship of these *Eriophyes* with 5- and 3-rayed featherclaws reported from *Ulmus* in North America and Europe is given by Keifer (1965). The species are very closely related but only the study of their life histories will throw light to such relationships.

South Dakota collection record:

Host	Location	Date	Collector
Ulmus americana	Brookings Co.	8/3/69	M. L. Briones
	Yankton Co.	8/18/69	M. L. Briones

Genus *Mesolox* Keifer

Mesolox Keifer, 1962, Calif. Dep. Agric., Eriophyid Studies B-5:11.
Genotype: *Mesolox tuttlei* Keifer

The most distinct characteristics of this genus are the central dorsal longitudinal ridge system and the furrow between the ridges that ends with the union of these two ridges at the posterior ¼. Dorsal setae divergent to the rear that are set in dorsolateral tubercles. Shield has a beak-like projection which extends over the rostrum, this is seen clearly in lateral view.

Mesolox tuttlei Keifer
Plate 37, Fig. 1-4; Plate 48, Fig. 4

Mesolox tuttlei Keifer, 1962. Calif. Dep. Agric., Eriophyid Studies B-5:11.

Type locality: Bay City, Michigan
Type host: *Parthenocissus quinquefolia*
Relation to host: The mites are undersurface leaf vagrants. In South Dakota the mites are numerous on both leaf surfaces causing severe browning and drying of Virginia creeper leaves. No damage noted in *Morus alba.*

South Dakota collection record:

Host	Location	Date	Collector
Parthenocissus quinquefolia	Yankton	9/9/69	M. L. Briones
Morus alba	Gayville	4/10/69	M. L. Briones

Genus *Phyllocoptes* Nalepa

Phyllocoptes Nalepa, 1889. Sitzb. Akad. Wiss. Wien, 98:116
Genotype: *Phyllocoptes carpini* Nalepa (by subsequent designation) Keifer, 1938, Bull. Calif. Dep. Agric., 27:191.

Mites in this genus have simple featherclaws; dorsal setae are ahead of the rear shield and directed centrally, upward or forward; and slight subdorsal furrows are present on the abdomen.

Representatives of species in this genus are usually vagrants on the undersurface of leaves, however, some species inhabit other areas of the host, in buds, petiole bases and fruits. Species in this genus have a wide geographical distribution.

Phyllocoptes arceuthi
Plate 24, Fig. 1-4; Plate 49, Fig. I

Phyllocoptes arceuthi Keifer, 1953, Bull. Calif. Dep. Agric., Eriophyid Studies 22:70.
Type locality: El Dorado Co., California
Type host: *Juniperus occidentalis*
Relation to host: The mites are in the crevices under the scale-like leaves on the twigs. Few specimens were collected from South Dakota during this study.

This species is related to *P. adalius*, but differs from it by having the shield pattern as lines rather than rows of granules. Perhaps this morphological difference is not significant and these two species may be conspecific.

South Dakota collection record:

Host	Location	Date	Collector
Juniperous virginiana	Brookings	7/20/70	M. L. Briones

Phyllocoptes didelphis Keifer
Plate 25, Fig. 1-6; Plate 46, Fig. 4

Phyllocoptes didelphis Keifer, 1954, Bull. Calif. Dep. Agric., Eriophyid Studies 22:125.
Type locality: Twin Bridge, El Dorado Co., California
Type host: *Populus tremuloides* Mihx. (Salicaceae) Aspen.
Relation to host: The mites form open erineum pockets on the leaf undersurfaces which appear as bulges on the upper leaf surface. The erineae is a cream-white irregular epidermal growth full of recesses. Mites are found at the bases of hairs forming this erineum. In South Dakota, the mites are in this same type of gall-erineum deformation (Fig. 14).

This mite is similar to *Phyllocoptes populi* Nalepa in Europe, which inhabits erineae on *Populus tremula; P. populi* has a 2-rayed featherclaw while *P. didelphis* has a 3-rayed featherclaw. The true relationships of these closely related species will not be known until the biology of each is investigated.

South Dakota collection record:

Host	Location	Date	Collector
Populus sp.	Black Hills at Hanna Creek	8/3/67	B. McDaniel

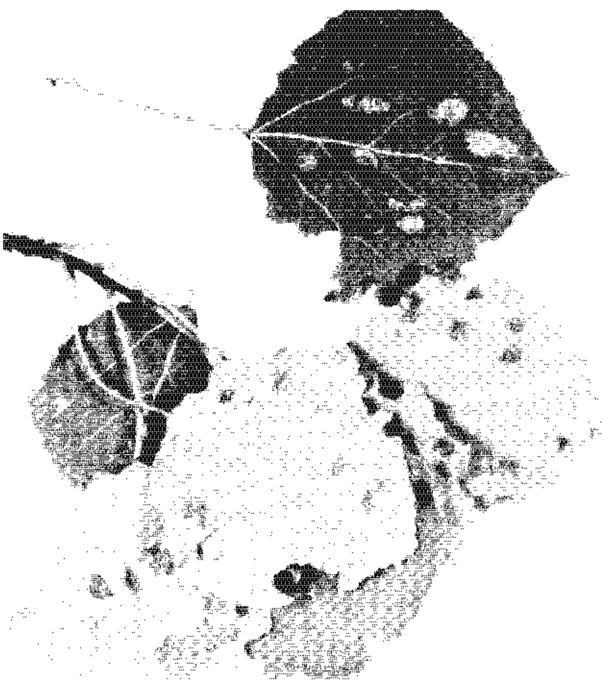


FIGURE 14. Open erinea pockets on leaves of *Populus* sp. caused by *Phyllocoptes didelphis* K.

Phyllocoptes microspinatus Hall
Plate 26, Fig. 1-5; Plate 4 6, Fig. 5

Phyllocoptes microspinatus Hall, 1967, Univ. Kansas Sci. Bull. 47:647.
Type locality: Iola, Allen Co., Kansas
Type host: *Juglans nigra*
Relation to host: Mites were taken from the lower surface of the leaf. No obvious damage to the host was observed. Mites from South Dakota were found on the undersurface of leaves along the midrib. No damage was noted.

This species is recognized by the shield pattern and the lateral designs on the shield. Since the South Dakota specimens were morphologically almost identical to Hall's *microspinatus*, they are placed under this species.

Host	**Location**	**Date**	**Collector**
Juglans nigra	Lake Goldsmith	6/5/69	M. L. Briones

Phyllocoptes slinkardensii Keifer
Plate 27, Fig. 1-4; Plate 49, Fig. 2

Phyllocoptes slinkardensii Keifer, 1966, Bull. Calif. Dep. Agric., Eriophyid Studies B-21:21.
Type host: *Rosa ultramontana*
Type locality: Slinkard Canyon, Topaz district, Mono Co., California.
Relation to host: The mites are found on the petiole bases of the host with "witches' broom" symptom.
According to Keifer (1966) graft tests have shown that the witches' broom symptom is caused by a virus and *P. slinkardensii* could be a vector. In South Dakota the mites are found vagrant on the petiole bases and undersurface of the leaves. The host showed no witches' broom symptoms but the plants were rather stunted and the leaves and petiole rusted.

This species is extremely close to *P. fructiphilus* K. from *Rosa californica* and differs only in shapes of microtubercles. *P. slinkardensii* has the microtubercles produced as definite spinules while *P. fructiphilus* has rounded or somewhat conical in shape. The South Dakota specimens fits very well with the description of *P. slinkardensii* hence it is being placed there, however, this difference in the shapes of microtubercles with *P. fructiphilus* may be morphological variation and these species may be conspecific. This is another case of a probably complex species whereby only biological study can clarify their true taxonomic position.

South Dakota collection record:

Host	**Location**	**Date**	**Collector**
Rosa sp.	Brookings	8/12/69	M. L. Briones

Genus *Platyphytoptus* Keifer

Platyphytoptus Keifer, 1938. Bull. Calif. Dep. Agric., 27: 188.
Genotype: *Platyphytoptus sabiniana* Keifer, 1938. Bull. Calif. Dep. Agric., 27: 188.

This genus is characterized by the dorsoventrally flattened body; abdomen subdivided by a sublateral groove into a tergum and sternum from just above the genitalia running caudad and fading out ahead of 3rd ventral setae. The legs with 6 segments; featherclaw simple; anterior coxae separated. Female genitalia with a short coverflap.

Only a few species are known in this genus and these are from California and Kansas. Hall (1967b) indicated that at least one species of *Platyphytoptus* occurs throughout the United States.

Platyphytoptus sabiniana Keifer
Plate 37, Fig. 5-6; Plate 47, Fig. 3

Platyphytoptus sabiniana Keifer, 1938. Bull. Calif. Dep. Agric., 27:188.
Type locality: Oroville, California
Type host: *Pinus sabiniana*
Relation to host: Mites are usually found on the needle sheaths. Scarification of the needles is the only type of damage noted. In South Dakota, the mites are found at the scarified tip of the needles. This scarification does not appear to harm the the host.

South Dakota collection record:

Host	**Location**	**Date**	**Collector**
Pinus sylvestris	Brookings	10/5/69	M. L. Briones

Additional hosts listed by Hall (1967).

Genus *Vasates* Shimer

Vasates Shimer, 1869. Trans. Am. Entomol. Soc. 2:319.
Type of Genus: *Vasates quadripedes* Shimer, 1869, Keifer 1944, Bull. Calif. Dep. Agric., 33:25 (By subsequent designation).

The genus is characterized by an anterior shield lobe over the rostrum, and with smooth tergites about as numerous as the microtuberculated sternites. The dorsal tubercles are on the rear shield margin, directing the dorsal setae caudad; the genital female coverflap smooth. Species occur commonly in Europe, in North America and Southeast Asia.

Vasates quadripedes Shimer

Plate 35, Fig. 1-6; Plate 48, Fig. 5-6

Vasates quadripedes Shimer, 1869, Trans. Am. Entomol. Soc., 2:319.
Phytoptus quadripedes Osborn, 1879. Iowa State College Quart., 2:32.
Phytoptus quadripedes Garman, 1882. Ill. State Entomol. Rpt. 12:135.
Eriophyes quadripedes Banks, 1901. Am. Econ. Entomol., 7:106.
Phyllocoptes quadripedes Parrot, Hodgkiss, Schoene, 1906 N. Y. Expt. Sta. Bull. No. 283.
Vasates quadripedes Shimer. Keifer, 1944. Bull. Calif. Dep. Agric., 33:25.
Relation to host: These mites produce bladder-like galls on the upper surface of the leaves (Fig. 15). This condition is quite common in the foliage of maple in South Dakota. Early in the summer the gall color is green becoming pink or red, and later turning black, eventually drying up the leaves. Some leaves are so heavily affected with galls that a premature abscission occurs. The galls range from as few as 5 up to 60 in a single leaf. Size of the galls varies from 2 to 5 mm in length.

Another type of damage noted in maple is the formation of a pink erinea on the underleaf surface (Fig. 16).

South Dakota Collection record:

Host	**Location**	**Date**	**Collector**
Acer saccharum	Brookings	7/12/67	M. L. Briones
	Mitchell	7/?)69	B. H. Kantack

Vasates gleditsiae Keifer

Plate 36, Fig. 1-5; Plate 48, Fig. 3

Vasates gleditsiae Keifer, 1959, Bull. Calif. Dep. Agric., Eriophyid Studies 26:275.
Type locality: Alexandria, Virginia
Type host: *Gleditsiae triacanthos*
Relation to host: These rust mites are often associated with new growth on dying trees. Heavy infestation noted. In South Dakota, the mites are found along the midrib on the undersurface of leaves and are often associated with *Anthocoptes bakeri.*

Vasates gleditsiae has a 5-rayed featherclaw and network-like shield pattern. Microtubercles are elongated on tergites and project unevenly from the annuli. Tergites are wider than sternites.

South Dakota collection record:

Host	**Location**	**Date**	**Collector**
Gleditsia triacanthos	Gayville	6/24/69	M. L. Briones
	Brookings	7/24/70	M. L. Briones

FIGURE 15. Leaf galls produced by *Vasates quadripedes* Shimer on *Acer saccharum* leaves.

FIGURE 16. Erinea on undersurface of *Acer saccharum* leaf caused by *Vasates quadripedes* Shimer.

Genus *Phytoptus* Dujardin 1851

Phytoptus Dujardin 1851, Ann. Sci. Nat. 3, Zool. 15:155.
Genotype: *Phytoptus tiliae* Pagenstecher, 1857, Verh. Ver. Heidelburg 1:46.
Type host: *Tilia platyphyllos*
Phytocoptes Donnadieu 1876, Ann. de las Soc. Linneene 26:153-155.
Eriophyes von Siebold, 1851, Keifer, 1938, Bull. Calif. Dep. Agric., 27-301.
Phytoptus Dujardin, Newkirk and Keifer 1971, Eriophyid Studies C-5:1-2.

This genus is characterized by the paired setiferous shield tubercles which are more or less ahead of the rear shield margin directing the setae ahead or up. Female genitalia somewhat appressed to the coxae; female genital coverflap longitudinally furrowed and anterior genital apodeme much shortened in ventral view.

Phytoptus brownei (Keifer)

Plate 29, Fig. 1-4; Plate 43, Fig. 3

Eriophyes brownei Keifer, 1966, Bull. Calif. Dep. Agric., Eriophyid Studies B-17:7-8.
Phytoptus brownei (Keifer) Newkirk and Keifer, 1971, Eriophyid Studies C-5.
Type locality: Gold Hill, Medford district, Oregon
Type host: *Symphoricarpus rivularis*
Relation to host: The mites are found in the leaf edgerolls. Some of these take the form of central leaf rolls. In South Dakota the mites are found in the buds and leaf axils and no damage noted at the time of collection.

This mite is characterized by the 6-rayed featherclaw, pointed microtubercles projecting over the ring margins, admedian shield lines not pointed across center and the first setiferous coxal tubercles opposite anterior coxal approximation. Dorsal tubercles set a little ahead of rear margin and the axis somewhat longitudinal.

South Dakota collection record:

Host	**Location**	**Date**	**Collector**
Symphoricarpus Occidentalis	Lake Oakwood	8/23/69	M. L. Briones

Phytoptus emarginatae (Keifer)

Plate 30, Fig. 1-7; Plate 47, Fig. 4

Eriophyes emarginatae Keifer, 1939, Bull. Calif. Dep. Agric., 28:144-145.

Type locality: 5 miles west of Tragedy Springs at Maiden's Grove, Amador County, alt. 8000, California.
Type host: *Prunus emarginata*

Keifer described the female of *P. emarginatae* in 1939 giving the following characters: absence of ring microtubercles, very short beak and type of leg segments. Oldfield (1969) studied the biology and morphology of this species associated with finger galls on *Prunus*. The galls observed were similar to the galls found in South Dakota (Fig. 17). Information on the existence of a possible univoltine type of life history in eriophyids is also discussed in his papers. At least three different species of *Prunus* are reported to have the finger galls caused by *P. emarginatae* in western United States according to Oldfield.

South Dakota Collection record:

Host	**Location**	**Date**	**Collector**
Prunus virginiana	Lake Oakwood	8/23/69	M. L. Briones

FIGURE 17. Leaf galls on *Prunus virginiana* caused by *Phytoptus emarginatae* (K.).

Phytoptus prunidemissae (Keifer)
Plate 30, Fig. 8-11; Plate 47, Fig. 5

Eriophyes prundemissae Keifer, 1956, Bull. Calif. Dep. Agric., 24:159.
Type locality: Forest Home District, San Bernardino Co., California.
Type host: *Prunus virginiana* var. *demissa*
Relation to host: Keifer (1956) reported that these mites live in the terminal buds and have no apparent relation to leaf galls of the same hosts. Observation made by Oldfield (1969) showed that *P. prunidemissae* mites reproduced in apical and subapical buds of western choke cherry early in the growing season in Southern California. He also noted that later in the season, these mites invaded the galls produced by *Phytoptus emarginatae* (K) on western choke cherry and produced another generation. Individuals of *P. prunidemissae* outnumbered *P. emarginatae* in most of the galls by late summer.

In South Dakota, *P. prunidemissae* was found in galls associated with *P. emarginatae* only on *Prunus virginiana*.

South Dakota collection record:

Host	**Location**	**Date**	**Collector**
Prunus padus	Yankton	7/9/68	M. L. Briones
Prunus virginiana	Lake Oakwood	7/23/69	M. L.Briones

Mites from *Prunus padus* were collected from the base of leaf petioles, while those from *Prunus virginiana* were from finger galls. (Fig. 17).

Genus *Tegonotus*[2] Nalepa

Tegonotus Nalepa 1890, Anz. Akad. Wien, 27:213.
Oxypleurites Nalepa 1891, Denk. Akad. Wiss. Wien, 58:868.
Genotype: *Tegonotus heptachanthus* Nalepa 1889, Zoologica 24:271.

Members of this genus are characterized by the more or less acute lateral projections formed by individual tergites which are smooth, broad and much less numerous than the sternites. The dorsal setae may be variable. The telosome of the abdomen is more or less evenly downcurved. This genus although not commonly collected seems to have a wide range. Representative species of this genus are known from Europe, Asia and United States. This group has not been reported to contain economically important species.

Tegonotus aesculifoliae (Keifer)
Plate 32, Fig. 1-5; Plate 47, Fig. 6

Phyllocoptes aesculifoliae Keifer 1938, Bull. Calif. Dep. Agric., 27:307.
Oxypleurites carinatus Keifer 1938, Bull Calif. Dep. Agric., 27:312.

[2]Refer to Newkirk and Keifer (1971) for the revision of this genus and genotype.

Oxypleurites aesculifoliae Keifer 1938, Bull. Calif. Dep. Agric., 27:312-313.
Oxypleurites neocarinatus Keifer 1939, Bull. Calif. Dep. Agric., 28:152.
Tegonotus aesculifoliae Newkirk and Keifer 1971, Eriophyid Studies C-5.
Type locality: Near Novato, Marin Co., California
Type host: *Aesculus californicus*
Relation to host: The mites cause some silvering of the leaves. No discernible damage by this species was noted on the host at the time of collection. The mites were found under bud scales.

Keifer (1938) described *P. aesculifoliae* from *Aesculus californica*. The following year he described *Oxypleurites neocarinatus* from the same host. Subsequent biological studies made by Keifer (1952) on these populations showed that two types of females exist in species; the protogyne or summer form which he had named *O. neocarinatus* and a deutogyne which he had named *O. aesculifoliae*. According to a later revision by Newkirk and Keifer this species is now *Tegonotus aesculifoliae*. Keifer was the first worker on eriophyids to recognize deutorogyny.

Tegonotus lindenus n. sp.
Plate 33, Fig. 1-6

This species is typical of the *Tegonotus* group by having the lateral tergites tooth-like or accentuated as well as the much enlarged tergites. *T. carinatus* Keifer possessed the same central arch on shield and portions of abdomen but differs from it in number of featherclaws and shield design. Perhaps the most important characteristic to separate this new species from the other described *Tegonotus* is the missing first coxal seta.

Female 120-120u long, 40-50u wide. Body flattened and wedgeshape. Rostrum 10-15u long, projecting down. Shield 30-32u long, broadly subtriangular, slightly arch centrally, the arch with scattered distinct granules. Dorsal tuberculated seta located at rear shield margin, seta 10-13u long, somewhat pointing forward and converging median. Distance between dorsal tubercles ca. 9-10u. Antapical seta 2-3.5u long. Abdomen with 19-20 enlarged smooth tergites which is toothlike at ventral view. Abdominal sternites consist of ca. 59-60 rings, microtuberculated. The size of the microtubercles small, somewhat pointed on ring margins. Towards the ventral telosome there is a progressive elongation of the microtubercles. Lateral seta 20-25u long on 9-11 ring from behind the coxae; VS_1, 35-40u long on 13-16 ring from LS; VS_2, 10-15u long on 15-16 ring from VS_1; VS_3, 30-31u long on 4-6 ring from rear. Accessory seta ca. 20u long. Forelegs: Femur length 6-7u, with 5-6u long seta; patella 4-5u long; tibial seta 5u long; tarsus

4-6u long; claw 7u long; featherclaw 6u long and 4-rayed. First coxal seta appears to be missing; second coxal seta 9-12u long; third coxal seta 32-35u long. Coxae with sparsely distributed dots and transverse fine lines. Hindlegs: Femur length 6-7u; femoral seta 4-5u long; patella 4-5u long; tibia 4-5u long; tarsus 5-6u long; claw 7u long; featherclaw 6u long and 4-rayed. Female genitalia 12-14u long and 20-24u wide; genital seta 8-10u long; genital coverflap with 5-6 longitudinal lines.

Males are about the same size and shape as the females. Width of male genitalia ca. 16u; genital seta 6u long. First coxal seta also missing; second coxal seta 10u long; third coxal seta ca. 20u long.

Type host: *Tilia linden*
Type locality: Brookings, South Dakota
Date collected: 6/8/69
Collector: M. L. Briones
Relation to host: The mites are vagrants on the undersurface of the leaves.
Materials examined: A type slide with above data, 6 partatype slides.

Genus *Tetra* Keifer

Tetra Keifer 1944, Bull. Calif. Dep. Agri., 33:27

Genotype: *Tetra concava* (K) 1939, Bull. Calif. Dep. Agri. 28(7):489

Members of this genus are characterized by the anterior shield lobe lacking spinules. The thanosome with wide middorsal longitudinal furrow or trough. Subdorsal ridges not joining ahead of telosome. Originally found in California, they are known to be upper surface vagrants in vein depressions on *Ulmus procera* Salisbury.

Tetra mcdanieli n. sp. Briones
Plate 31, Fig. 1-4; Plate 52

The species is closely related to *T. calamorphae* K., from *Amorpha californica*. Main distinction from *T. calamorphae* are: the distinct shield pattern, acuminate shield lobe and structure of the microtubercles on sternites which progressively elongate on tergites. *T. americana* from *Ulmus americana* has 6- to 7-rayed featherclaw as does this species but with shorter dorsal seta, terminally rounded shield lobe and different shield pattern. As in *T. calamorphae* and *T. americana* this species has the broad dorsal trough.

Female 160-250u long, avg 214u; 55-60u thick, avg 57u; flattened-fusiform in shape. Rostrum 25u long, bent down; antapical seta 5-6u long. Shield 30-35u long, triangular in shape, with anterior lobe acuminate. Shield design distinct, median line missing from anterior ¾; admedian lines complete, curved, converging posteriorly joining the posterior median line then arched outward rather evenly; anterior ⅓ and in middle of shield has rather granulated outline of arch extending to lateral shield. Posterior of the shield and between the dorsal tubercle, the submedian lines connected at rear by short cross dashes. Also, there is a distinct submedian line parallel the admedian which is slightly curved out ending a short distance from ahead of dorsal tubercle. Dorsal tubercle ca. 2u long with dorsal axis transverse to body; dorsal seta 20-23u long projected backward and somewhat diverging caudally; distance between dorsal tubercles 20u. Coxae ornamented with granules and short dashes; first coxal seta ca. 14u long, with distance between tubercles slightly wider than the second; second coxal seta 20-25u long, tubercles located near the first coxal posterior angle; third coxal tubercles widely spaced, located at rear angle of coxal approximation and parallel the cross line between them; third coxal seta 40-50u long, avg 46u long; coxal sternal line distinct, slightly forked anteriorly. Forelegs: tarsus 7u long; tibia 7u long ca. 7-8u long seta on middle; patella 5u long; femur 8-9u long with 9-10u long seta. Claw 8-9u long; featherclaw 7-9u long, with 6-to 7-rayed. Hindlegs: tarsus 6-7u long; tibia 7-8u long; patella 5u long; femur 8-9u long, with 9-10u long seta. Female genitalia 13-15u long and 12-16u wide; genital seta 25-35u long; genital coverflap with 10-13 longitudinal lines. Thanosome with ca. 30-40 tergites with somewhat faint microtubercles which progressively elongate dorsally; tergites broader than sternites. Sternites with small bead-like microtubercles along margin of rings. Lateral seta 15-30u long on 10-14 sternite annuli; VS_1, 30-55u long on sternite 12-14 from LS; VS_2, 30-45u long on sternite 18-21 from VS_1; VS_3, 22-30u long on sternite 20-23 from VS_2, and 4 annuli from anal lobe. Number of microtubercles per 10u arc between VS_1, 6-7; between VS_2, 7-8; between VS_3, 4-5. Accessory seta 3u long.

Male 160-210u long, avg 185u; ca. 50u thick. Male genitalia 14-16u wide; genital seta 15-25u long. Males are similar to females, except that the featherclaw rays appear to be consistently 6-rayed.

Deutogyne noted and differentiated on the basis of complete absence of microtubercles.

The species is named after B. McDaniel, Acarologist, Entomology-Zoology Department, South Dakota State University.

Type locality: NW of Goldsmith Lake, South Dakota
Type host: *Amorpha fruticosa*
Date collected: 6/5/69
Collector: M. L. Briones
Relation to host: Mites are found in the leaf axils and flower buds at the base and among the hairs.
Materials examined: A type slide with above data, and 10 paratype slides.

Family: RHYNCAPHYTOPTIDAE Keifer

Genus: *Rhyncaphytoptus* Keifer

Rhyncaphytoptus Keifer, 1939, Bull. Calif. Dep. Agric., 28:149.
Type genus: *Rhyncaphytoptus ficifoliae* Keifer, 1939, Bull. Calif. Dep. Agric., 28:150.

The genus is recognized by the large, abruptly bent rostrum and long stylet. Sternites are normally more than tergites and the axis of the featherclaw is simple.

This genus is apparently widely represented. It is now known in North America, Europe and Asia.

Rhyncaphytoptus atlanticus Keifer
Plate 40, Fig. 1-3; Plate 49, Fig. 3

Rhyncaphytoptus atlanticus Keifer, 1959. Bull. Calif. Dep. Agric., Eriophyid Studies 28:17-18.
Type locality: Washington, D. C.
Type host: *Ulmus americana*
Relation to host: In South Dakota, the mites are undersurface leaf vagrants.

This species is close to *R. ulmivagrans* K. but differs by having 8-rayed featherclaws, shield pattern with median line, microtubercles more rounded, rostrum thicker and more blunt apically.

South Dakota collection record:

Host	Location	Date	Collector
Ulmus americana	Yankton	6/18/69	M. L. Briones

Rhyncaphytoptus strigatus Keifer
Plate 2, Fig. 3-4; Plate 49, Fig. 4

Rhyncaphytoptus strigatus Keifer, 1939. Bull. Calif. Dep. Agric., 28:228.
Type locality: Davis, California
Type host: *Acer negundo californicum*
Relation to host: The mite is a vagrant on the undersurface of the leaves, no damage was noted. In South Dakota, this mite is found on the undersurface of boxelder leaves, outside the erineum pouch caused by *Eriophyes calaceris* (K.)

South Dakota collection record:

Host	Location	Date	Collector
Acer negundo	Brookings Co.	7/11/69	N. L. Briones

Genus *Diptacus* Keifer

Diptacus Keifer 1951. Eriophyid Studies XVII:99.
Diptilomiopus Keifer, Keifer 1939. Eriophyid Studies IV:232.

Body elongate spindle form. Rostrum large, set at right angle to the cephalotborax, the large chelicerae abruptly bent down. Shield subtriangular with lobe over rostrum base. Dorsal tubercles present, set ahead of the rear margin, and directing setae ahead. Coxae with 3 pairs of setae,the forecoxae separated by a sternal ridge. Legs with all segments; femoral setae missing; forelegs with patellar and tibial setae; hindlegs with patellar seta. Featherclaw divided. Sternites more numerous than the tergites. All abdominal setae present. Female genitalia with smooth coverflap.

Diptacus pengsonae n. sp.
Plate 39, Fig. 1-9

The species is related to *D. sacramentae* K. and *D. floculentus* K. but differs from them by the dorsal shield design and shape, number and shape of the divided featherclaw and its central cleft, and shape of the microtubercles.

Female 220-250u long, avg 132u; 70u thick and 65-90u wide. Body robust spindle-form in shape. Rostrum 30-35u long; avg 32u; attenuated terminal shield; somewhat beneath the anterior lobe is a pair of very short setae. Shield 40-43u long, with network design consisting of ca. 8 irregularly formed cells. Lateral shield with lines of fine granulations. Dorsal tubercles located ahead of rear shield margin ca. 2u, axis of the tubercles lateral to the body; distance between dorsal tubercles 24-25u apart; dorsal setae 5u long converging mediad. Anterior coxae contiguous with almost no noticeable lines but with scattered fine granules. First setiferous coxal tubercles well ahead of second tubercles and but not well farther apart of the coxal tubercles; second coxal tubercles ahead of transverse lines. First coxal setae 16-20u long, avg 18u; second coxal setae 42-55u long, avg 48u long. Length of the genitalia 20-28u long, avg 26u long, about 36u wide; coverflap smooth, the anterior with fine scattered dots; genital setae 8-10u long, avg 9.5u long. Total number of abdominal tergites 56-62. Lateral setae 55-60u long on 16-19 abdominal sternites; VS_1, 67-83u long on 15-16 abdominal sternites from LS; VS_2, 37-80u long, avg 68u, on 19-26 sternites from VS_1; VS_3, 50-55u long, avg 53u on 11-12 abdominal sternites from VS_2. Abdominal microtubercles somewhat pointed ventrally, fewer to obsolete in number dorsally, attached to the posterior margin of the annuli. Number of microtubercles per 10u arc between VS_1, 4-7; between VS_2, 5-6; and between VS_3, 6-7.

Males similar to females, except that they are shorter; about 150u long and 65-70u wide. Genital setae about 7u long, Only two males collected in this study.

The species is named after T. Pengson.

Type locality: White, South Dakota
Type host: *Ribes missourinsis* (Saxifragaceae), gooseberry
Date collected: 8/12/69
Collector: M. L. Briones
Relation to host: Mites are leaf vagrants on the undersurface of the distorted and crumpled leaves.
Materials examined: A type slide with above data, 10 paratype slides.

Family: NALEPELLIDAE Newkirk and Keifer 1971
Genus: *Phytocoptella* Newkirk and Keifer

Phytocoptella Newkirk and Keifer 1971, Eriophyid Studies C5, USDA, ARS
Phytoptus Dujardin, 1851. Ann. Sci. Nat. S. 3 Zool. 15:155.
Genotype: *Phytoptus corniseminis* Keifer, 1939. Bull. Calif. Dep. Agric., 28:144.
Host of genotype: *Cornus nutali* Aud., western flowering dogwood.

This genus is characterized by the following: body wormlike, thanosomal annuli subequal dorsoventrally. Short form oral stylet. Cephalothoracic shield not projected over rostrum, with four shield setae; an anterior pair located near the antero-lateral edge; the other pair of dorsal seta arising from tubercles situated ahead of rear shield margin; dorsal setae projecting up if short, ahead when long. Legs with all standard setae, usually with apico-lateral foretibial spur. Featherclaws simple. Coxae with three pairs of setiferous tubercles, forecoxae separated by sternal line. Thanosome and telesome with all standard setae and a pair of anterior subdorsal setae. Accessory seta present. Female genitalia with internal apodeme of moderate length; spermatheca long-oval, attached to short tubes that project diagonally ahead from rear central genital opening and then recurve.

This genus is represented by several species, the majority of which were described by Keifer and Nalepa, mainly from Austria and United States.

Phytocoptella rotundus (Hall)
Plate 38, Fig. 1-5; Plate 48, Fig. 1

Phytoptus rotundus Hall, 1967. Univ. Kansas Sci. Bull. 47:665.
Type locality: Franklin Co., Kansas
Type host: *Tilia linden*
Relation o host: All stages of the mites present in small irregular finger galls on both surface of the leaf. In South Dakota the mites have the same relationships to their host as reported by Hall in Kansas (Fig. 18).

P. rotundus is distinguished from its close relative *P. corniseminus* (K.) by the 3-rayed featherclaw. The true relationship of *P. abnormis* (Garman) to *P. rotundus* needs further study. The original description of *P. abnormis* was inadequate and lacks the illustration which will aid in the determination and correlation of these two species. Both species, *P. abnormis* and *P. rotundus* are reported from Tilia. The *Phytocoptella* species from South Dakota are placed under *P. rotundus* until further investigation on their biology is available.

South Dakota collection record:

Host	**Location**	**Date**	**Collector**
Tilia americana	Brookings	6/3/69	M. L. Briones

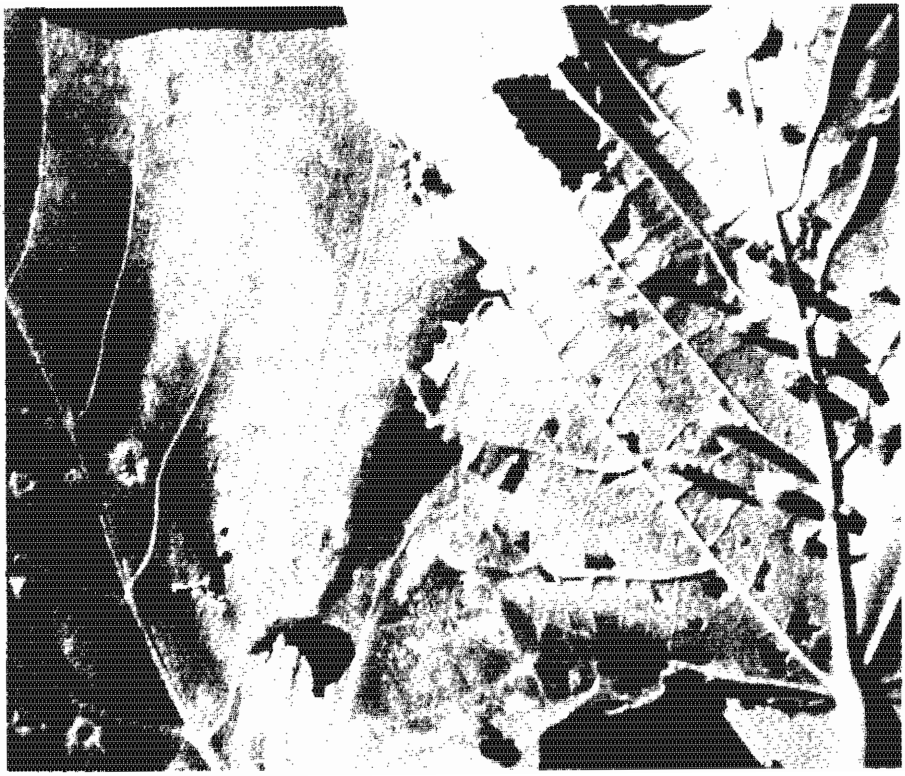


FIGURE 18. Leaf galls on *Tilia linden* caused by *Phytocoptella rotundus* (Hall).

SUMMARY

Presented here are results of a survey conducted from 1967-1970 to determine the species of eriophyid mites in South Dakota.

Eriophyids are vectors of several plant viruses and are known to produce other types of damage to their hosts, such as galls, blisters, rusting, witches'-broom, proliferation of tissues and leaf rolling. Therefore, attention was focused on collecting plants showing these obvious abnormalities. Many other plants not showing these symptoms were examined for free living eriophyid species.

Specimens were prepared and preserved following Keifer's method as well as other preservation techniques. Species discussed are illustrated with line drawings, photomicrographs and some scanning electron micrographs.

Taxonomic status of the different species was determined by comparison and correlation with the previously reported eriophyids. Problems were encountered in correlating these species with those recorded by European workers because of the loss of type materials and inadequate description available in the literature. Keifer's and those of others re-descriptions of the European and North American species were utilized in this study, as well as the records of host specificity. The use of host specificity, however, has its own limitation because of cases where a species of eriophyids had been reported on a number of not only closely related hosts, but also on plants of different families. Such is the case of *Eriophyes douglasiana* (Wilson and Oldfield) found in South Dakota, where it was collected on two host plants belonging to two different families.

Most of the previous workers gave little attention to variation or morphological features in the development of eriophyid classification. In the course of this study it was most interesting to note the variation of characters within a given population known to be a single species. Variations observed are discussed separately under each particular species. Also included are the interpretations of attributes of certain complex groups and a discussion of the probable conspecificity of some previously described species.

It is evident that biological studies are needed to clarify these morphological variations in many species. Perhaps emphasis should be placed on the biosystematic approach in treating the

taxonomy of Eriophyoidea. There are still many aspects unknown in the life histories of this group of Acarines that need to be learned.

The present study records 48 different species of eriophyid mites from South Dakota; six of these are described and named as new species.

A conspectus of the species reported in this paper is listed in each of the main families.

Family: ERIOPHYIDAE Nalepa 1898

1. *Abacarus hystrix* (Nalepa)
2. *Acarelliptus occidentalis* Keifer
3. *Aculodes dubius* (Nalepa)
4. *Aculodes mckenzie* (Keifer)
5. *Aculops laevigatae* (Hassan)
6. *Aculops lobuliferus* Keifer
7. *Aculops maximilianae* n. sp.
8. *Aculops tocicophagus* (Keifer)
9. *Aculus cornutus* (Banks)
10. *Aculus nigrus* Keifer
11. *Aculus schlectendali* (Nalepa)
12. *Anthocoptes bakeri* Keifer
13. *Anthocoptes punctidorsa* Keifer
14. *Calepitrimerus baileyi* Keifer
15. *Calepitrimerus vitis* Keifer
16. *Cecidophyes collegiatus* Keifer
17. *Cecidophyes pusilla* Keifer
18. *Eriophyes arceosae* n. sp.
19. *Eriophyes calaceris* (Keifer)
20. *Eriophyes celtis* Kendall
21. *Eriophyes chondriphora* (Keifer)
22. *Eriophyes douglasiana* (Wilson and Oldfield)
23. *Eriophyes mackiei* (Keifer)
24. *Eriophyes mori* (Keifer)
25. *Eriophyes neoartemisiae* (Keifer)
26. *Eriophyes parapopuli* (Keifer)
27. *Eriophyes parulmi* (Keifer)
28. *Eriophyes tulipae* Keifer
29. *Eriophyes taylori* n. sp.
30. *Eriophyes ulmi* (Keifer)
31. *Mesolox tuttlei* Keifer
32. *Phyllocoptes arceuthi* Keifer
33. *Phyllocoptes didelphis* Keifer
34. *Phyllocoptes microspinatus* Hall
35. *Phyllocoptes slinkardensii* Keifer
36. *Platyphytoptus sabiniana* Keifer
37. *Vasatesquadripedes* Shimer
38. *Vasates gleditsiae* Keifer
39. *Phytoptus brownei* (Keifer)
40. *Phytoptus emarginatae* (Keifer)
41. *Phytoptus prunidemissae* (Keifer)
42. *Tegonotus aesculifoliae* (Keifer)
43. *Tegonotus lindenus* n. sp.
44. *Tetra mcdanieli* n. sp.

Family: NALEPELLIDAE Newkirk and Keifer 1971

1. *Phytocoptella rotundus* (Hall)

Family: RHYNCAPHYTOPTIDAE Keifer 1961

1. *Rhyncaphytoptus atlanticus* Keifer
2. *Rhyncaphytoptus strigatus* Keifer
3. *Diptacus pengsonae* n. sp.

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Appendix

Symbols Used In Plates And Figures

Symbols refer to the structures in plates and figures.

ANT — Antapical seta
API — Internal female epodeme
AR — Abdominal ring or annuli
CG — Coxal granulations
CH — Chelicerae
CL — Claw
CS — Caudal seta
D — Dorsal view of mite
DA — Dorsal view of anterior section
DE — Side skin structure
DS — Dorsal seta
DT — Dorsal tubercle
ES — Lateral surface structures
F — Featherclaw
FM — Femur
FMS — Femoral seta
GC — Female genital coverflap
GF1 — female genitalia
GM — Male gentalia
GS — Genital seta
L1 — Anterior leg or first leg
L2 — Hind leg or second leg
LS — Lateral seta
MT — Microtubercles
PT — Patella
R — Rostrum
S — Side view of mite
SA — Side view of anterior section of mite
SH — Shield
T — Tibia
THA — Thanosome
TEL — Telosome
TS — Tibial seta

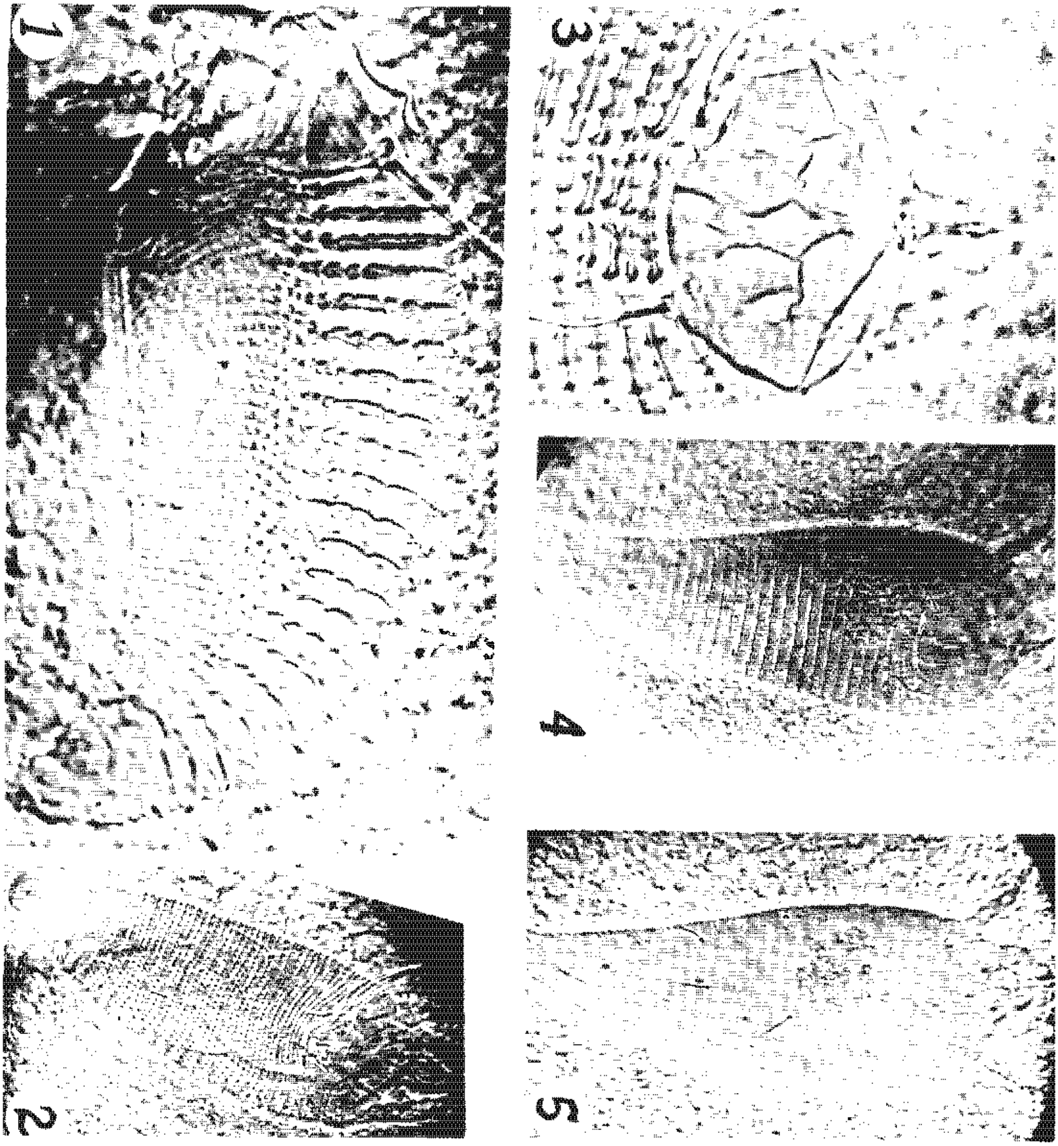


PLATE 1. Fig. 1-5. ***Anthocoptes punctidorsa*** **Keifer**

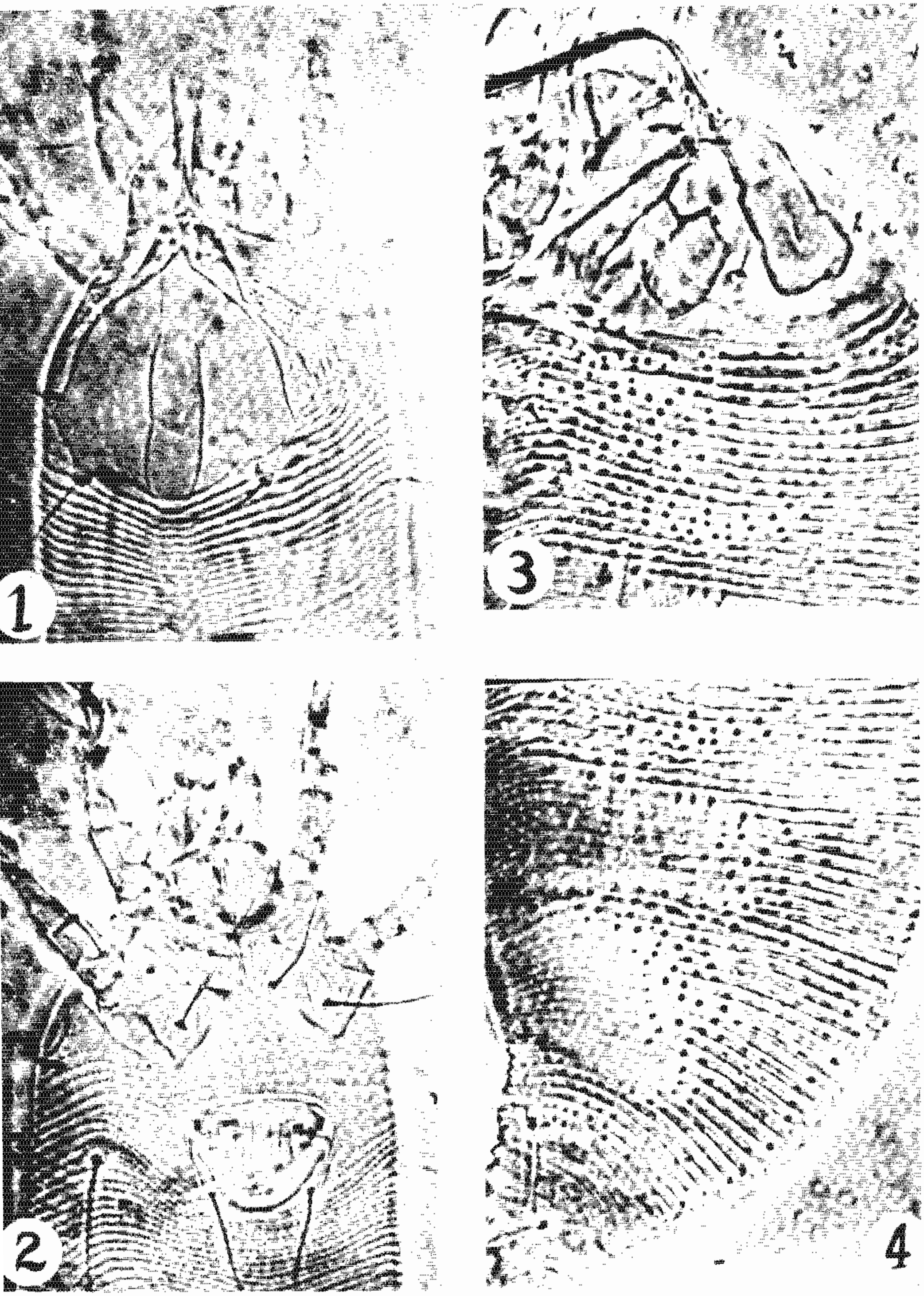


PLATE 2. Fig. 1-2. ***Abacarus hystrix*** **(Nal.). Fig. 3-4.** ***Rhyncaphytoptus strigatus*** (K.).

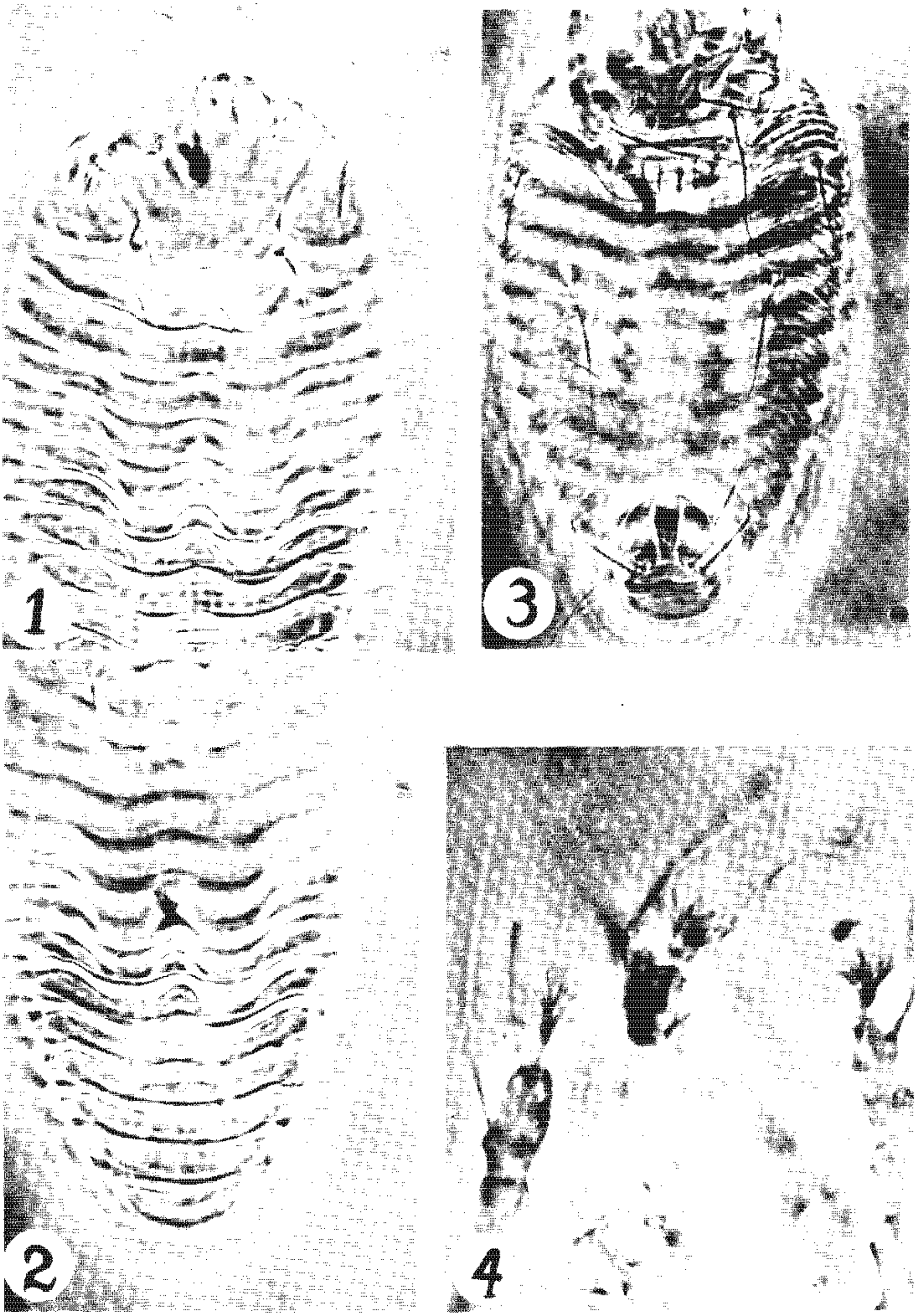


PLATE 3. Fig. 1-4. *Acarelliptus occidentalis* (K.).

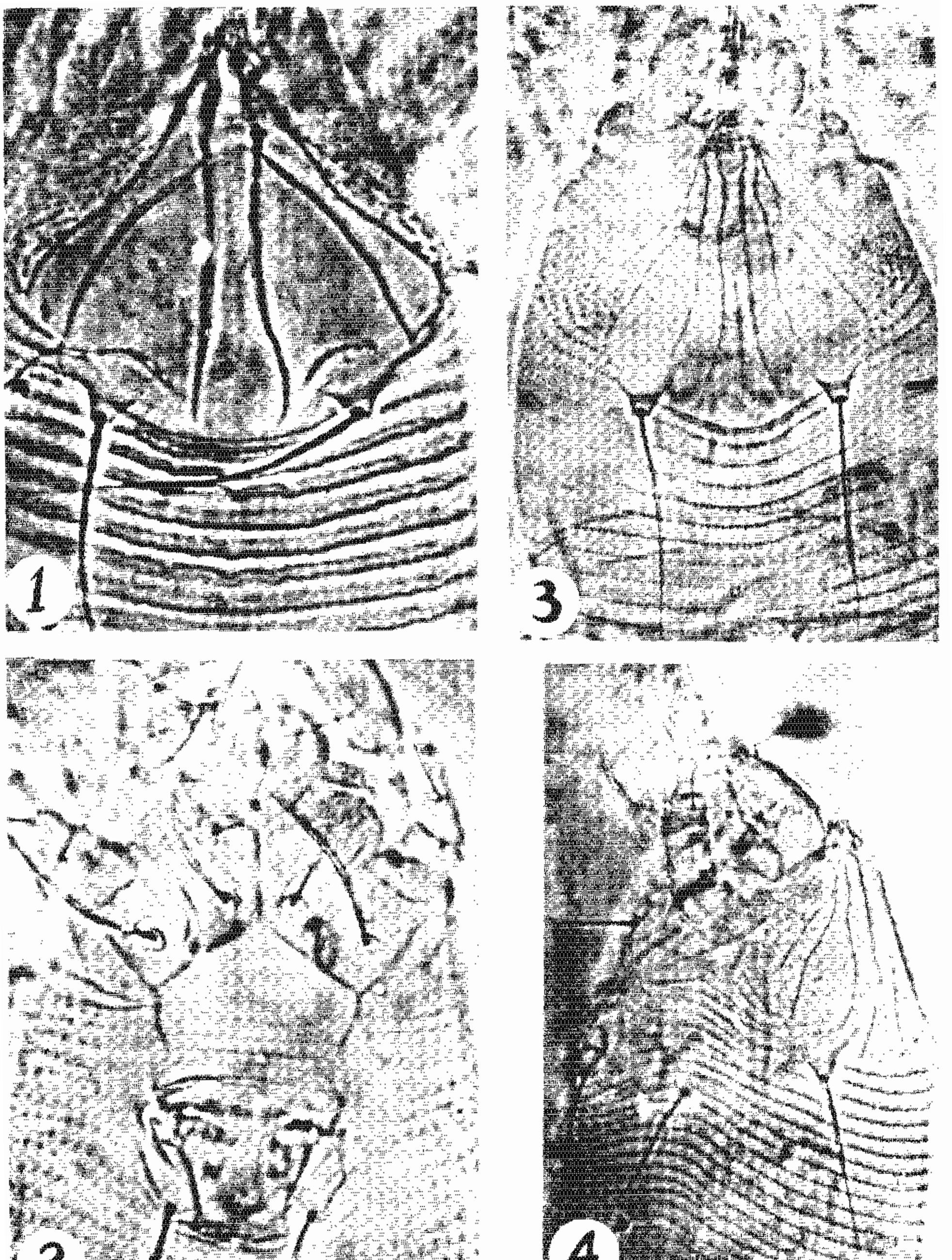


PLATE4. Fig. 1-2. *Aculodes dubius* (K.); Fig. 3-4 *Aculodes mckenzie* (K.).

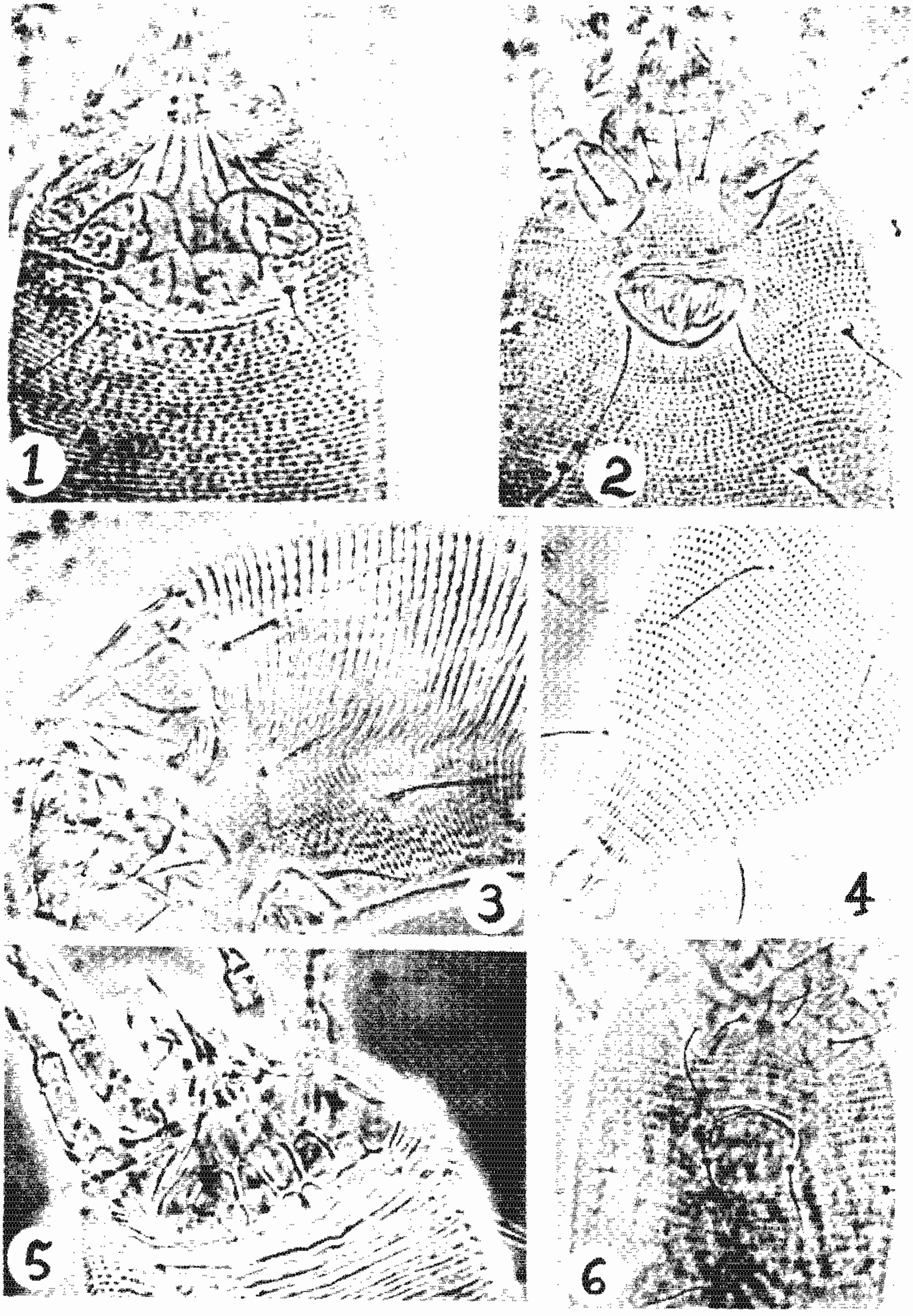


PLATE 5. Fig. 1-6. *Aculops laevigatae* (Hassan)

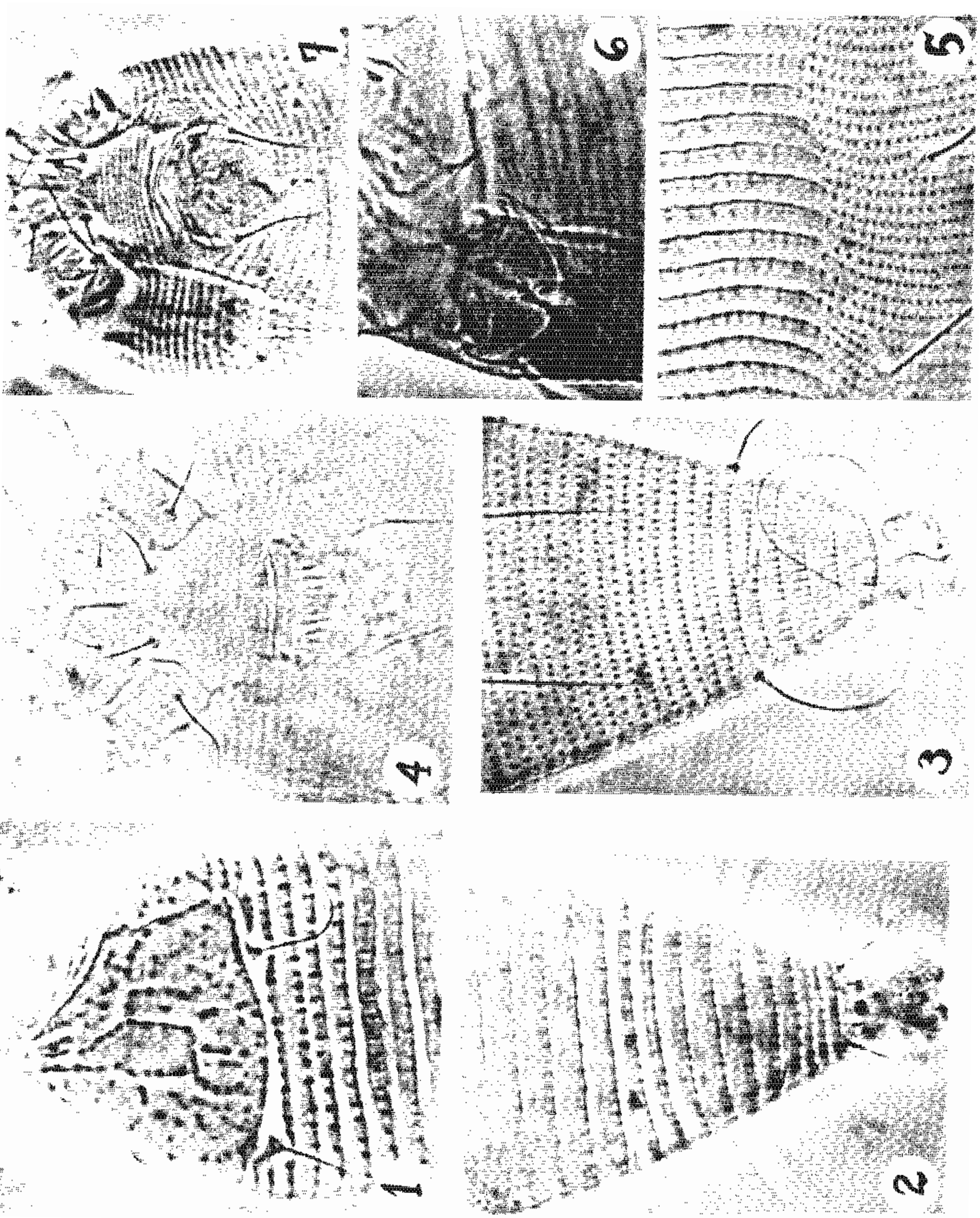


PLATE 6. Fig. 1-7 *Aculops lobuliferus* (K.).

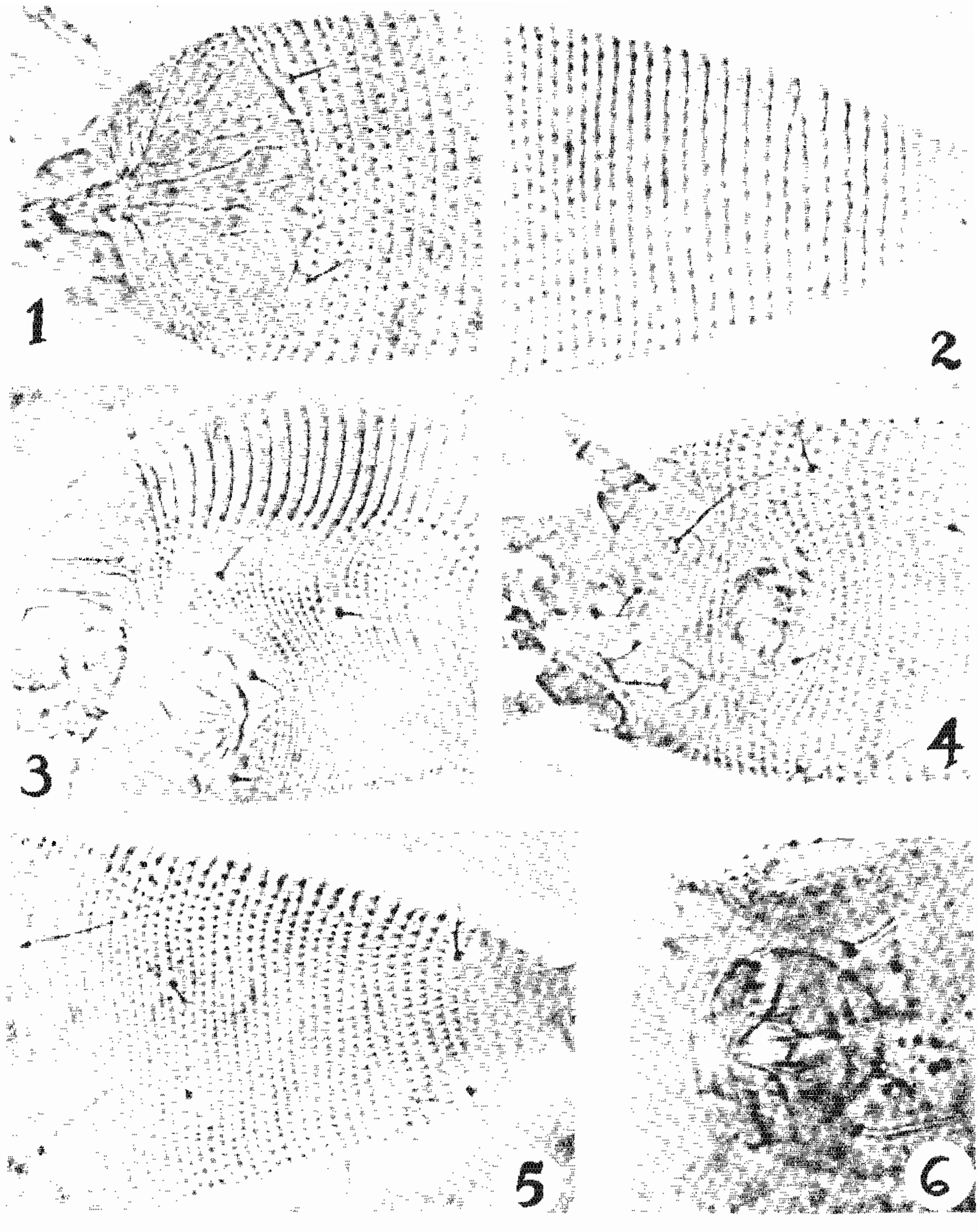


PLATE 7. Fig. 1-6. *Aculops maximilianae* n. sp.

PLATE 8. Scanning electron micrograph of featherclaw of *Aculops maximilianae* n. sp. (Taken at 10,000X).

PLATE 9. Fig. 1-3 *Aculops toxicophagus* (Ewing).

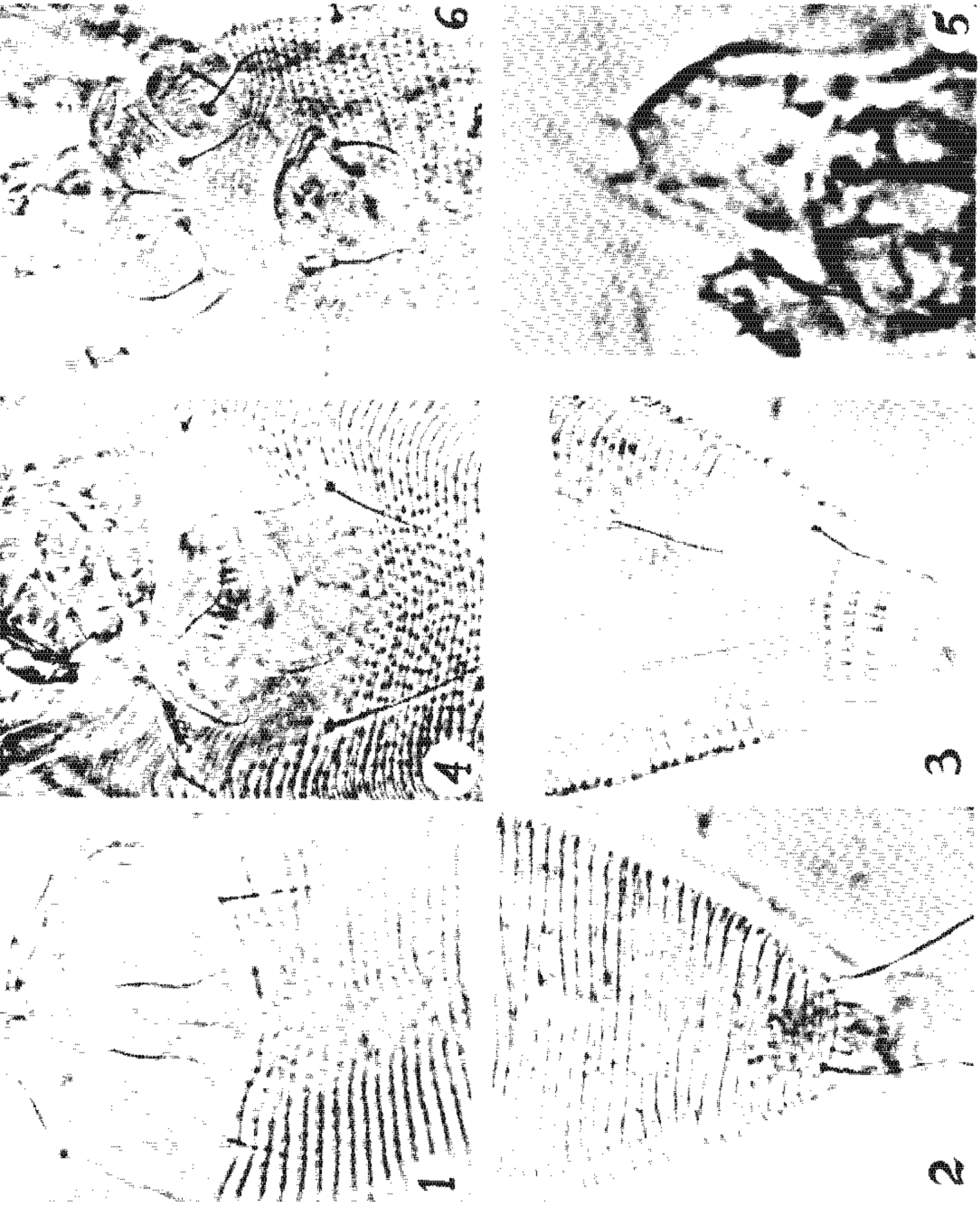


PLATE 10. Fig. 1-6. *Aculus cornutus* (Banks).

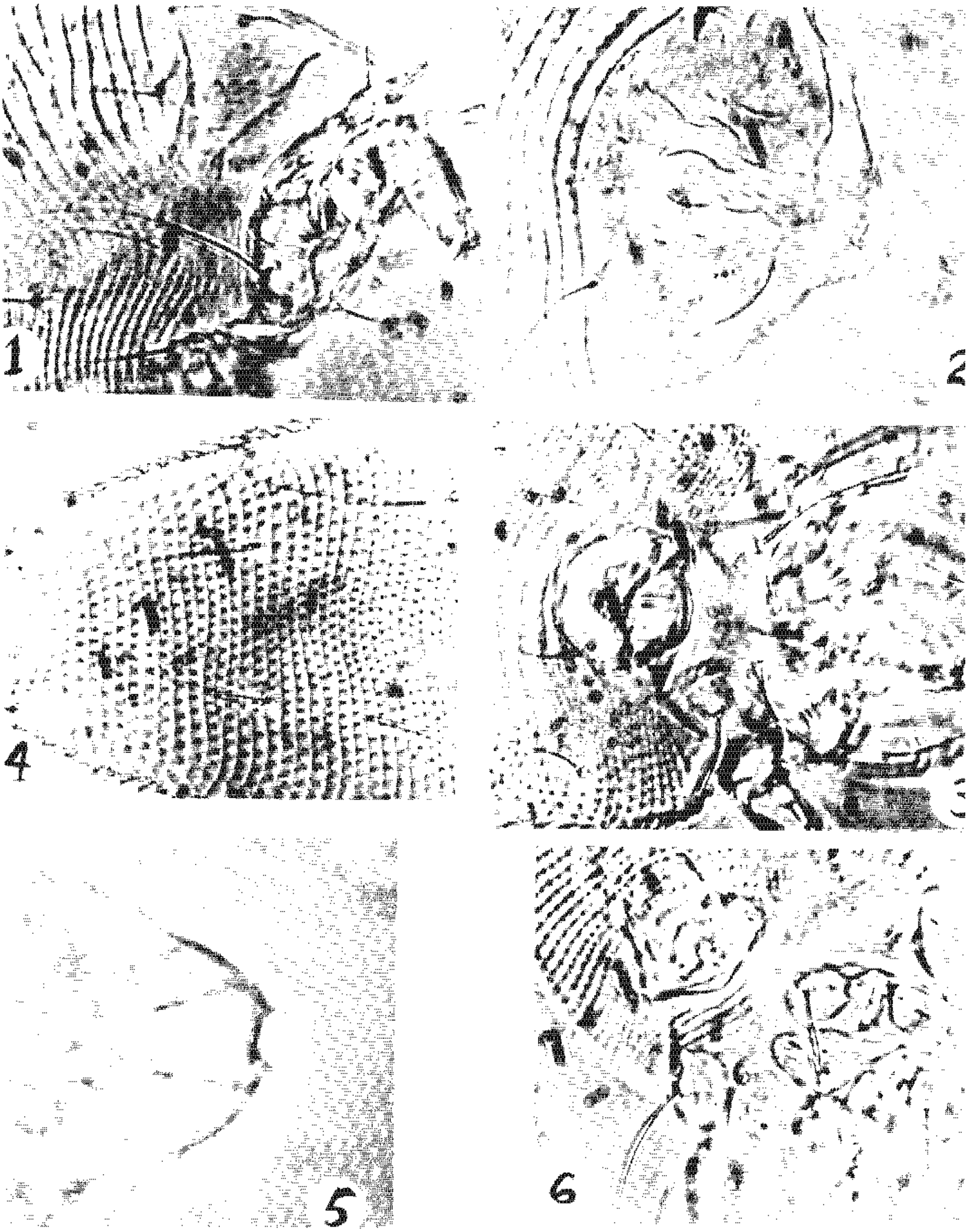


PLATE 11. Fig. 1-6. *Aculus nigrus* K.

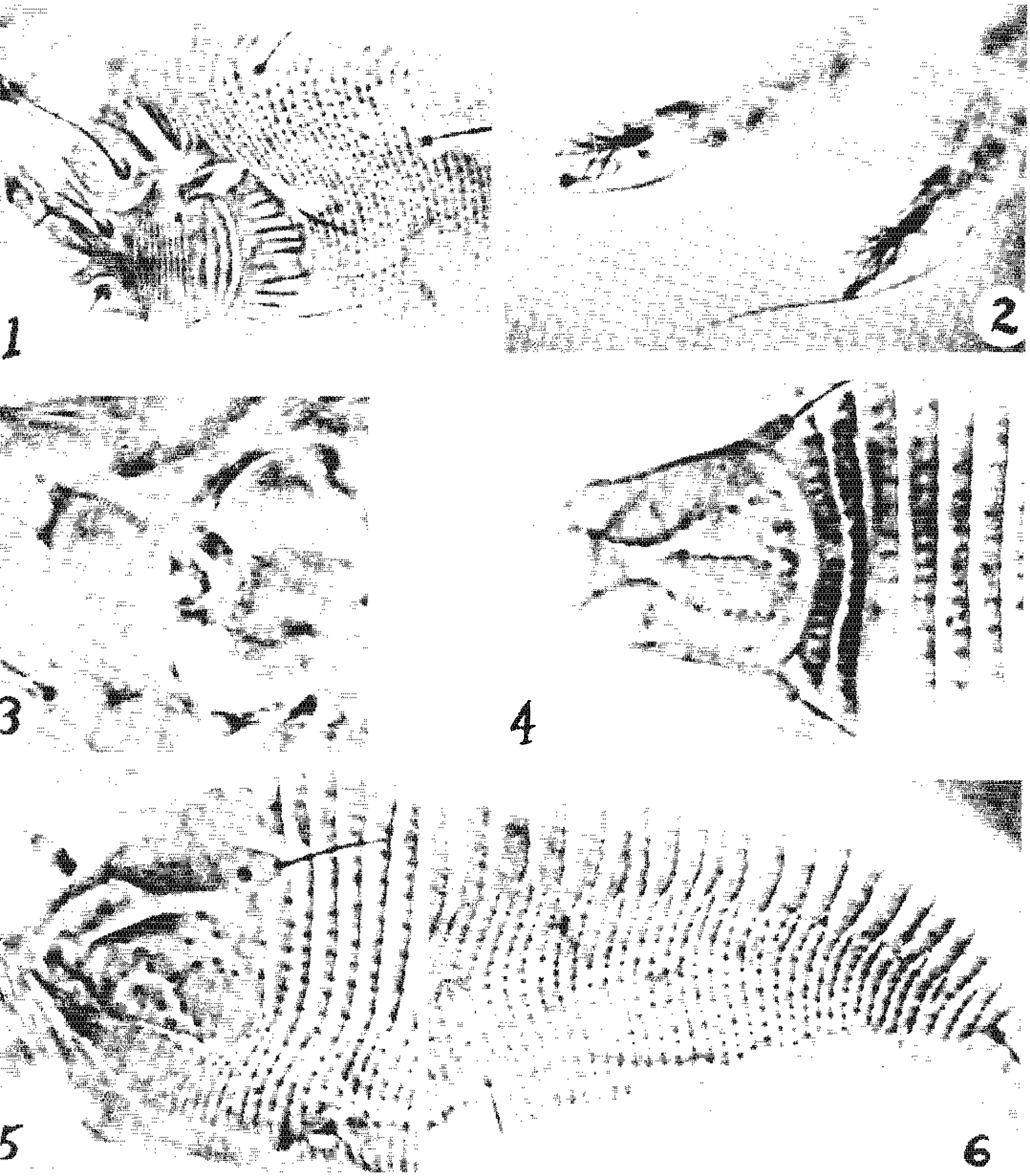


PLATE 12. Fig. 1-6. *Aculus schlectendali* (Nal.).

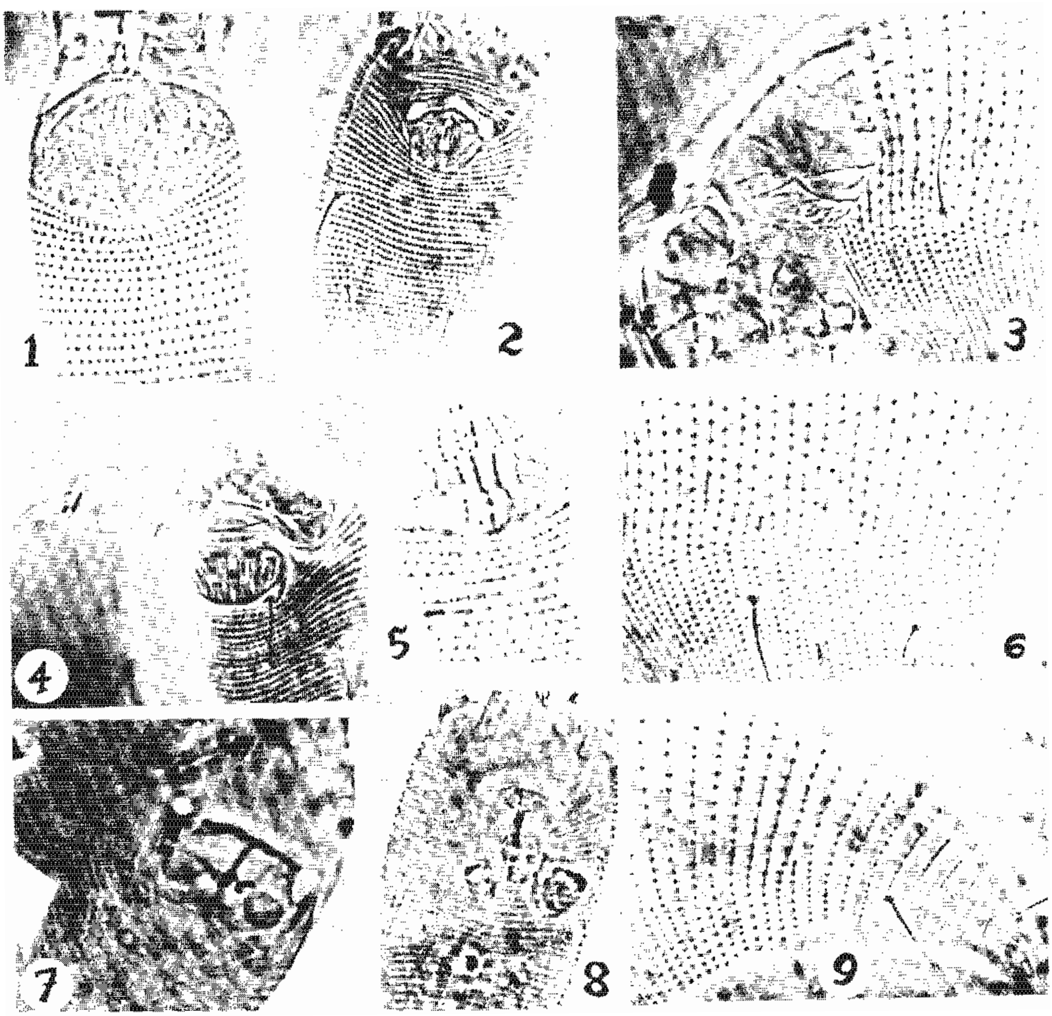


PLATE 13. Fig. 1-2, 4-5, 7-8. *Cecidophyes pusilla* K.; Fig. 3,6,9 *Cecidophyes collegiatus* K.

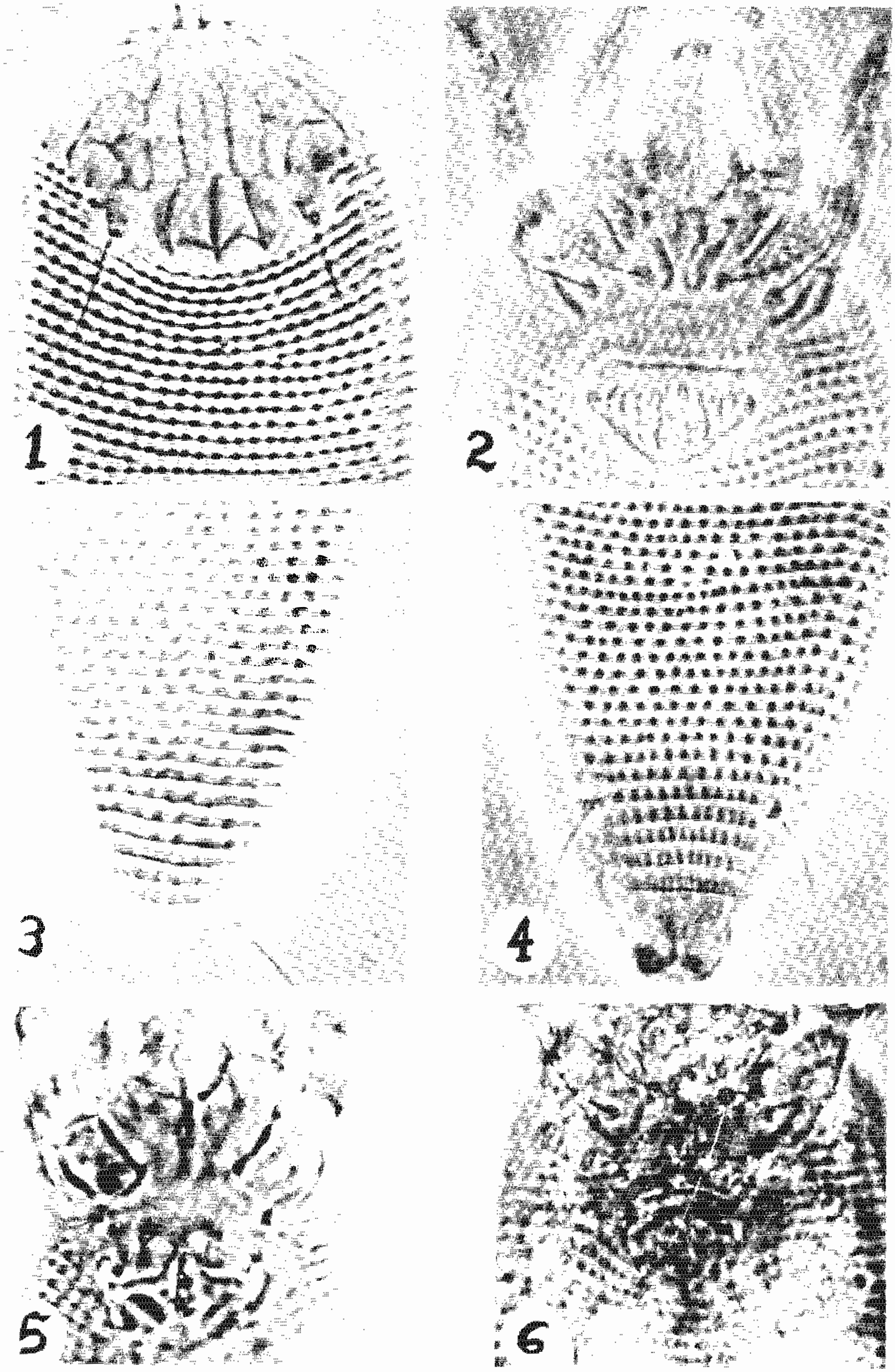


PLATE 14. Fig. 1-6. *Eriophyes arceosae* n. sp.

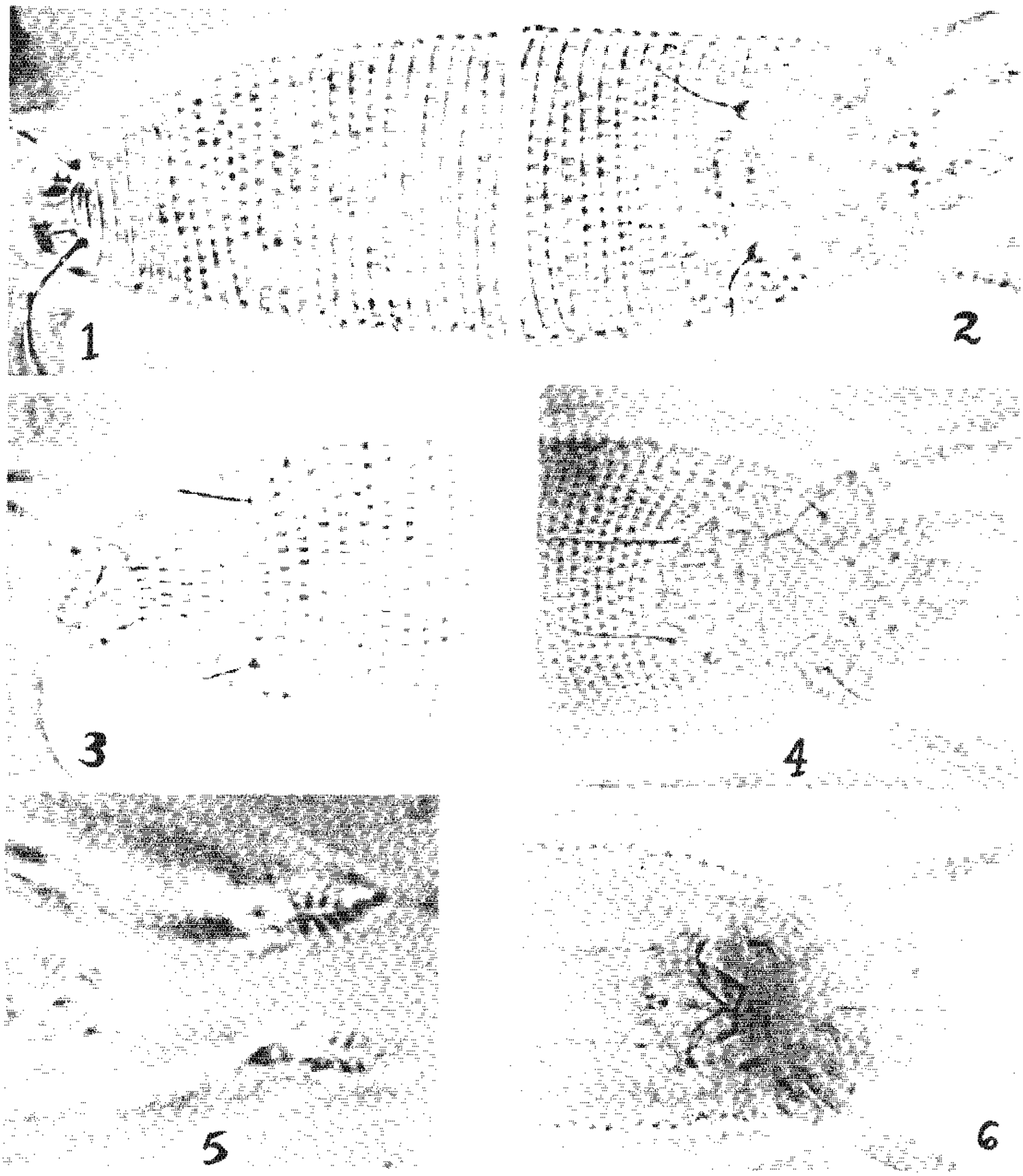


PLATE 15. Fig. 1-6. *Eriophyes celtis* Kendall.

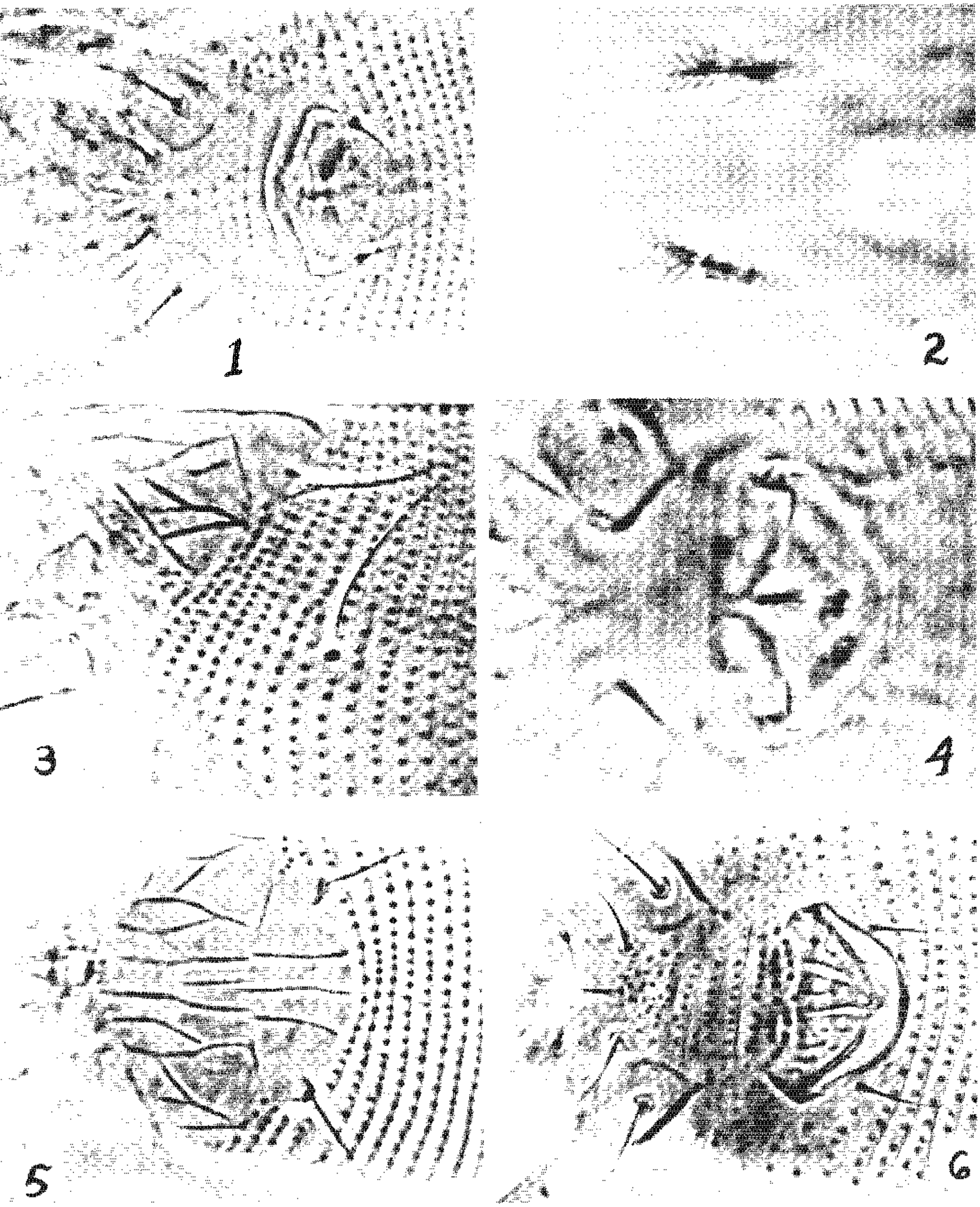


PLATE 16. Fig. 1-6. *Eriophyes douglasiana* (Wilson and Oldfield).

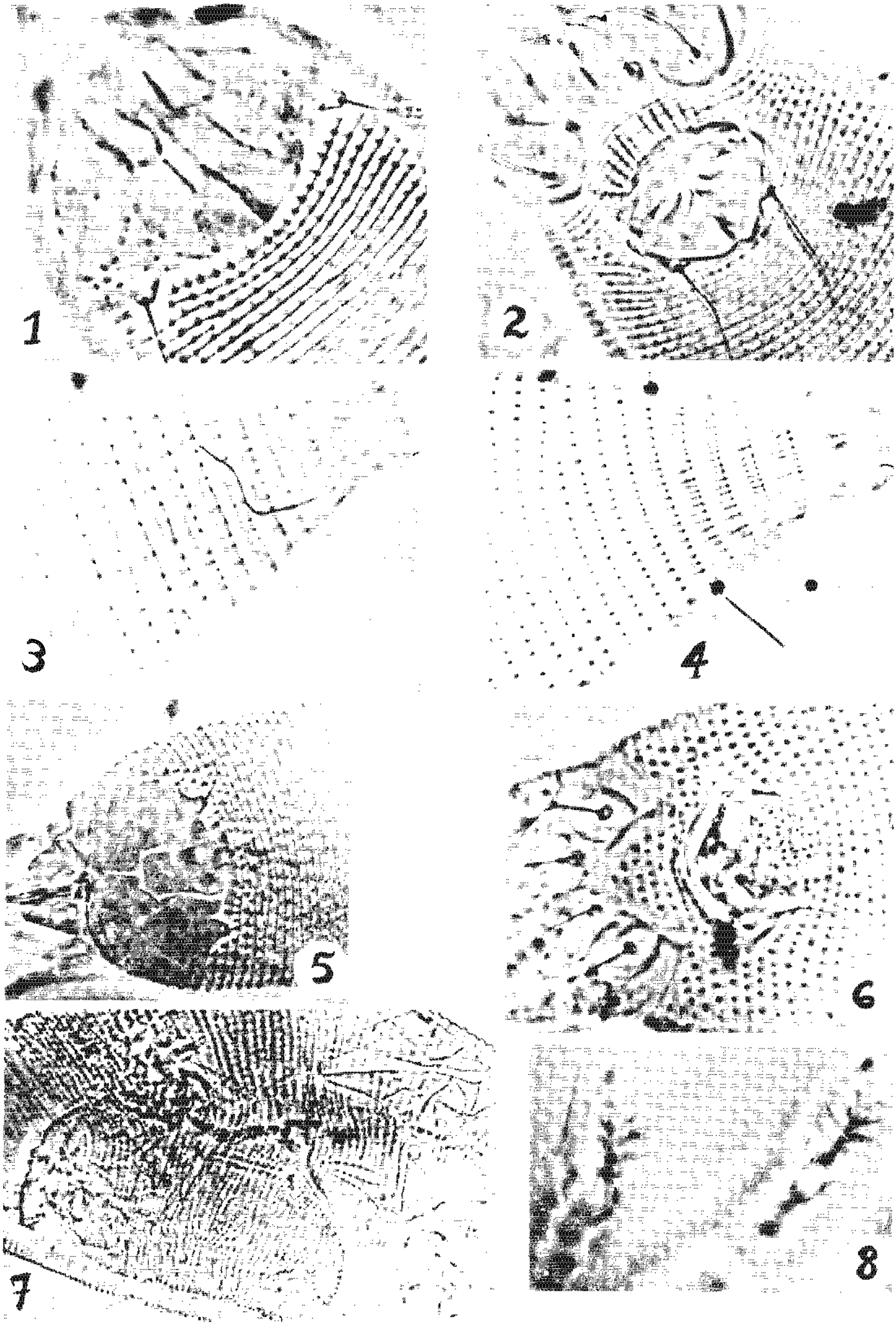


PLATE 17. Fig. 1-8. *Eriophyes chondriphora* (K.).

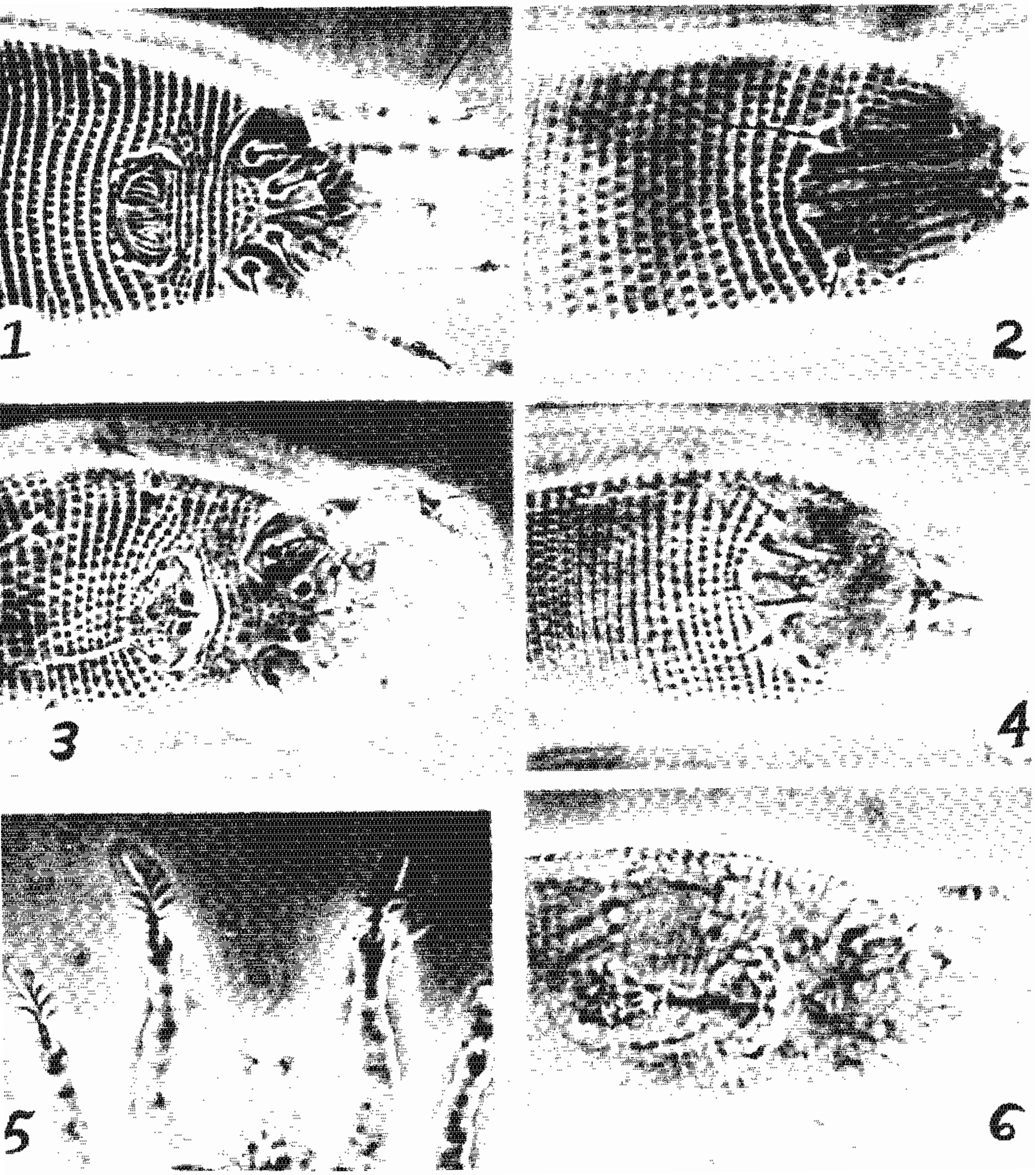


PLATE 18. Fig. 1-6. *Eriophyes mori* (K.).

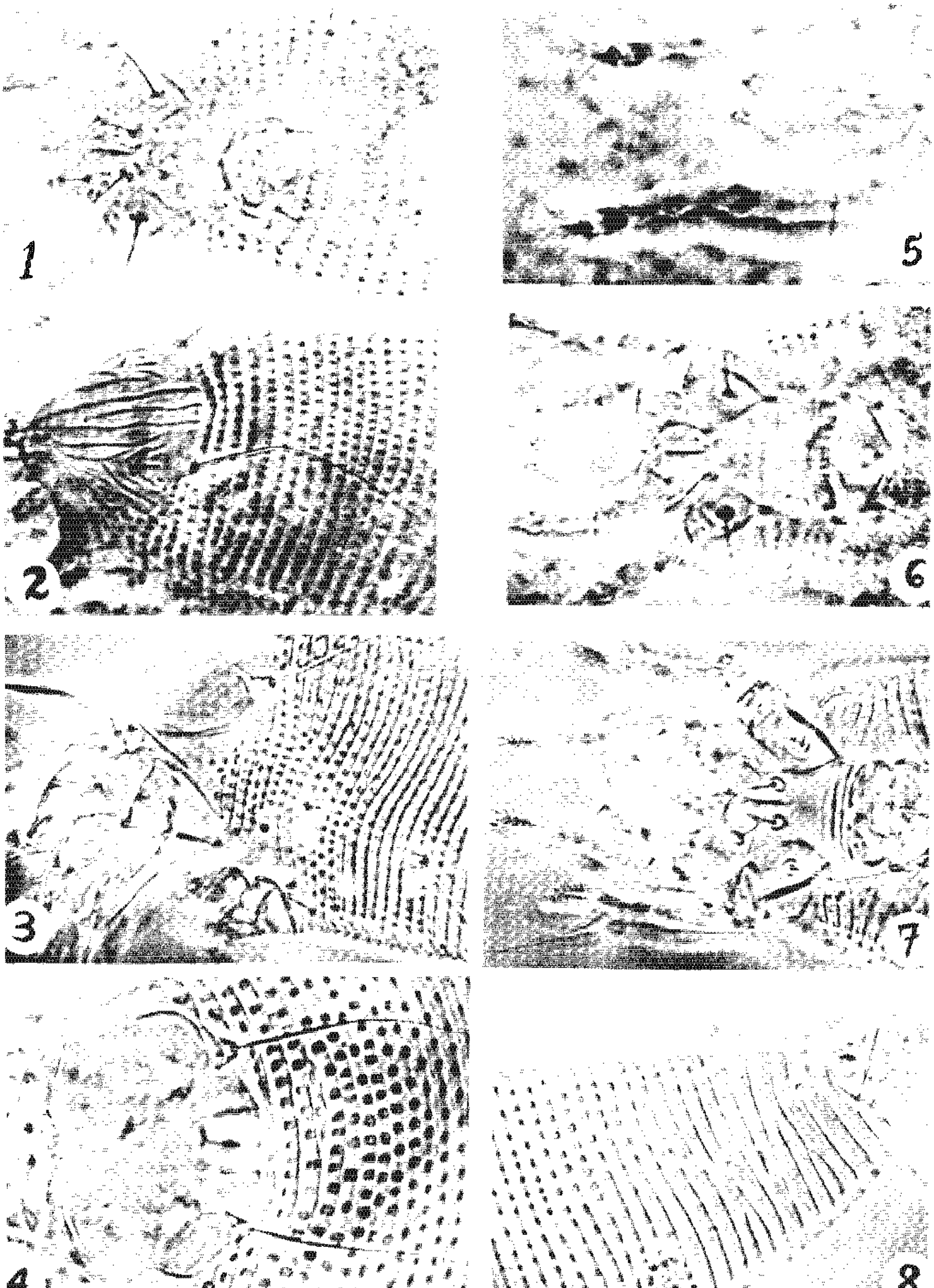


PLATE 19. Fig. 1-2, 7-8. *Eriophyes neoartemisia* (K.); Fig. 3-4, 5-6. *Eriophyes parapopuli* (K.).

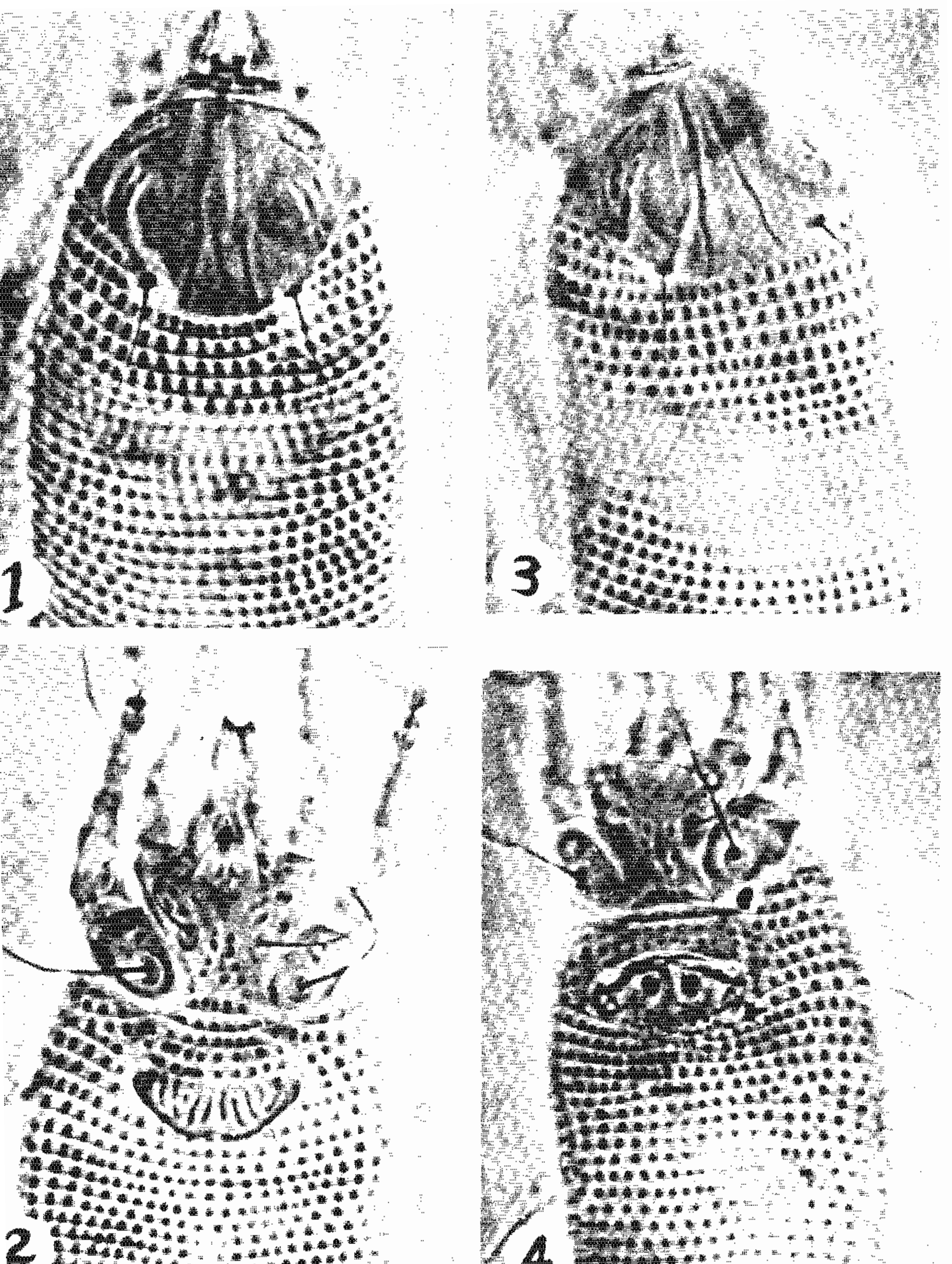


PLATE 20. Fig. 1-4. *Eriophyes mackiei* (K.).

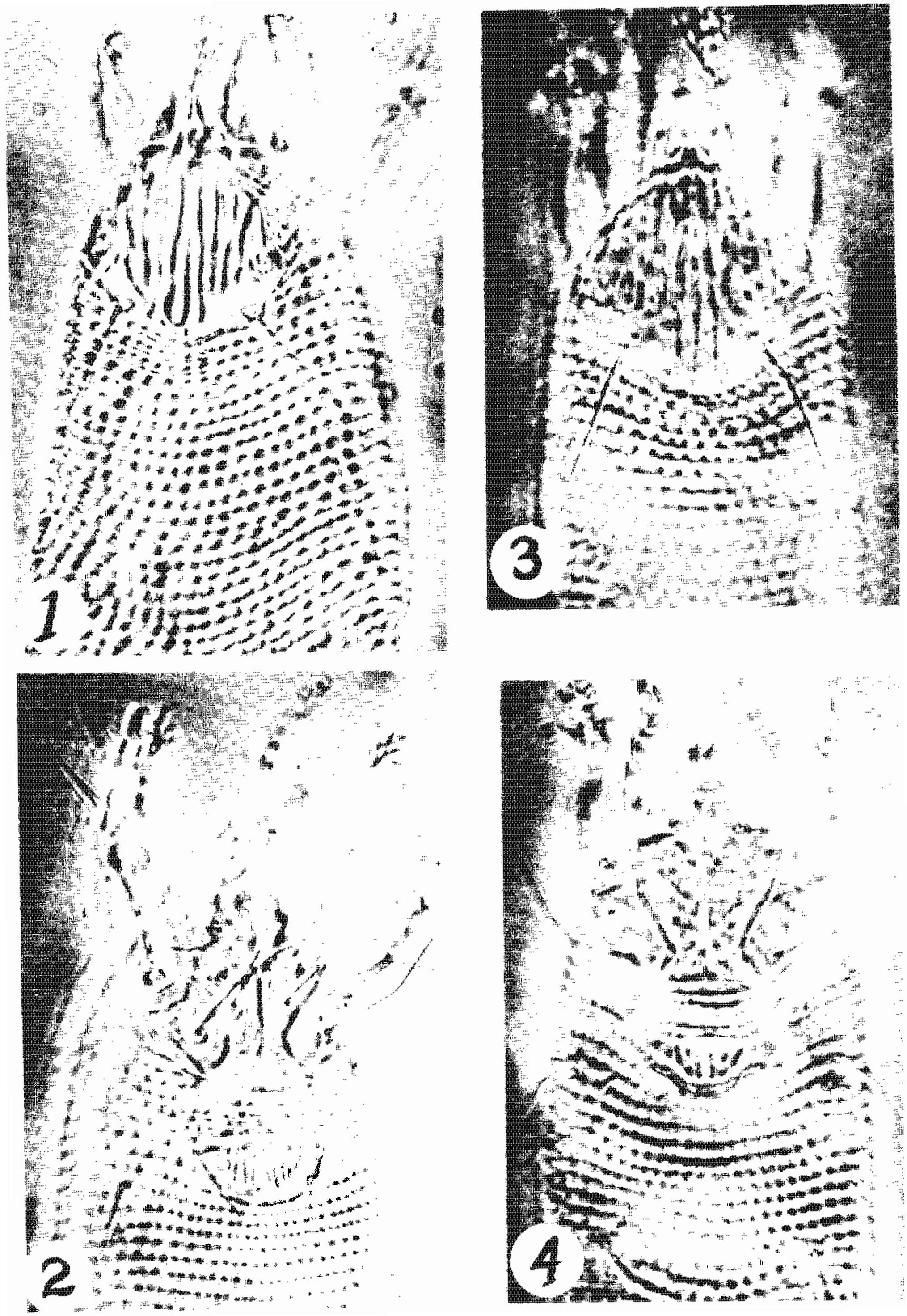


PLATE 21. Fig. 1-2 *Eriophyes ulmi* (K.); Fig. 3-4 *Eriophyes parulmi* (K.).

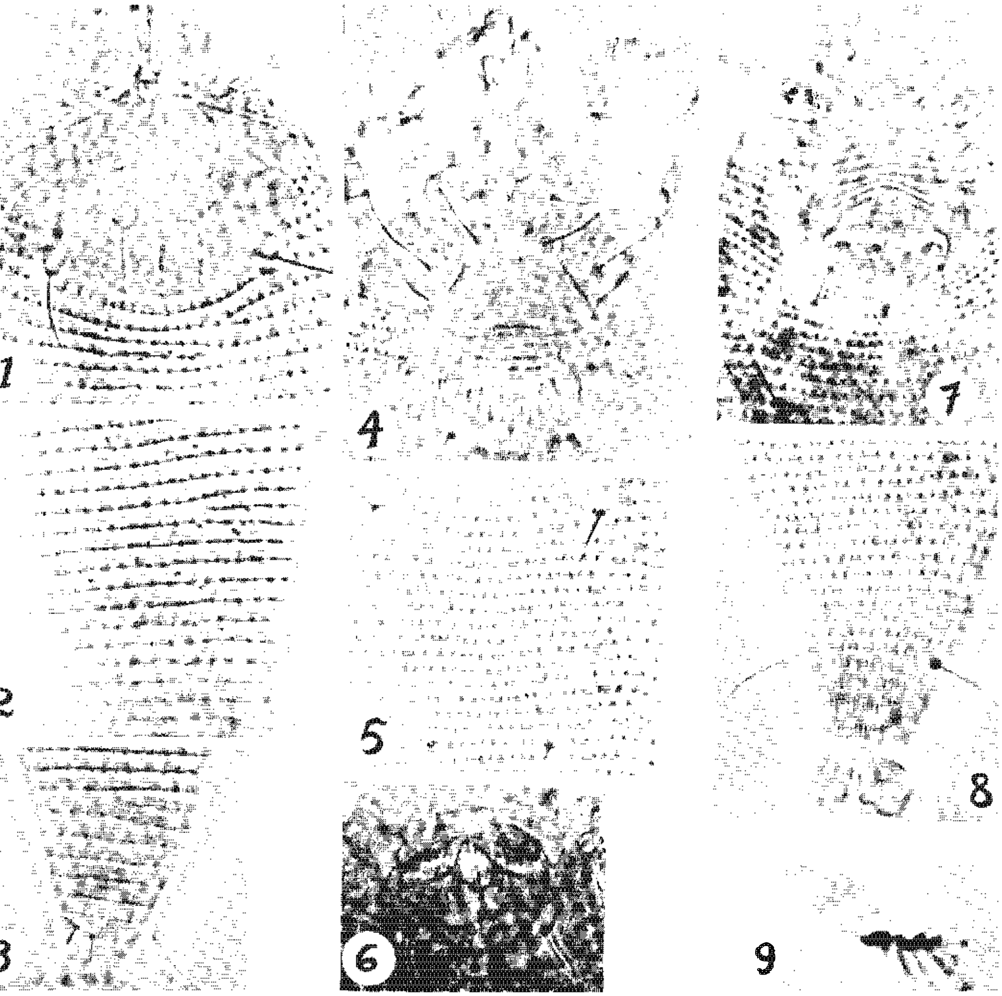


PLATE 22. Fig. 1-9 *Eriophyes taylori* n. sp.

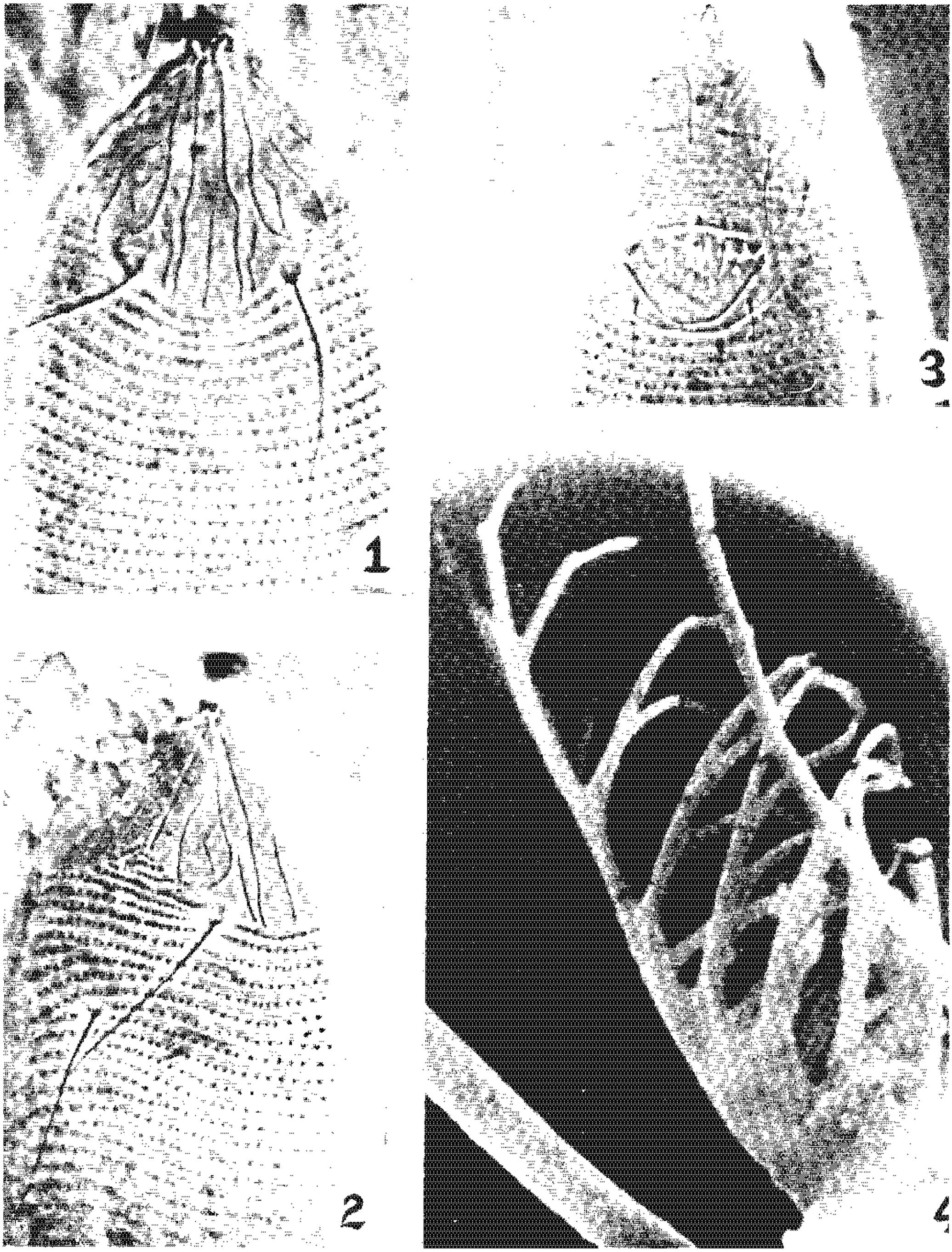


PLATE 23. Fig. 1-4 *Eriophyes tulipae* K.

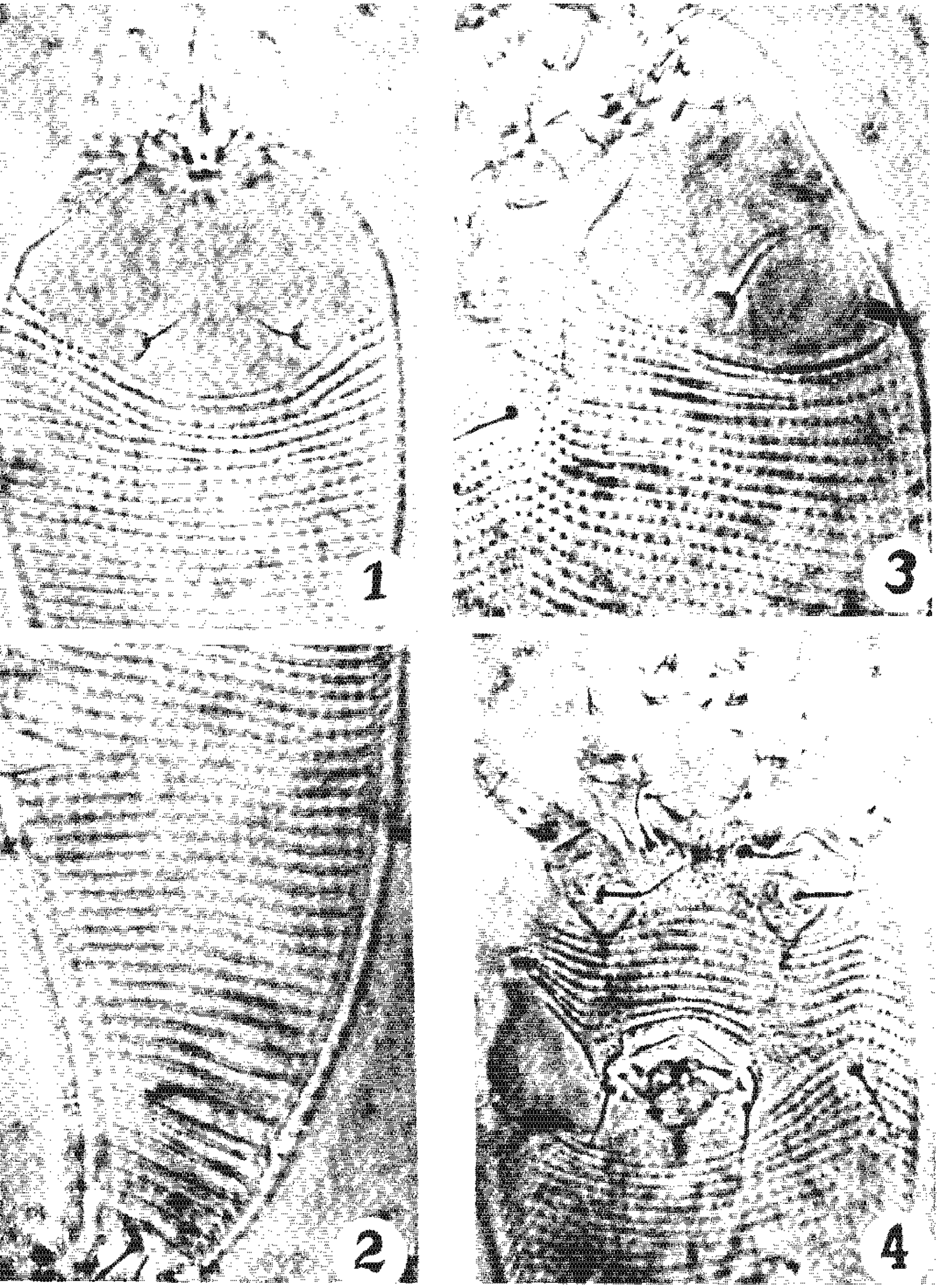


PLATE 24. Fig. 1-4 *Phyllocoptes arceuthi* K.

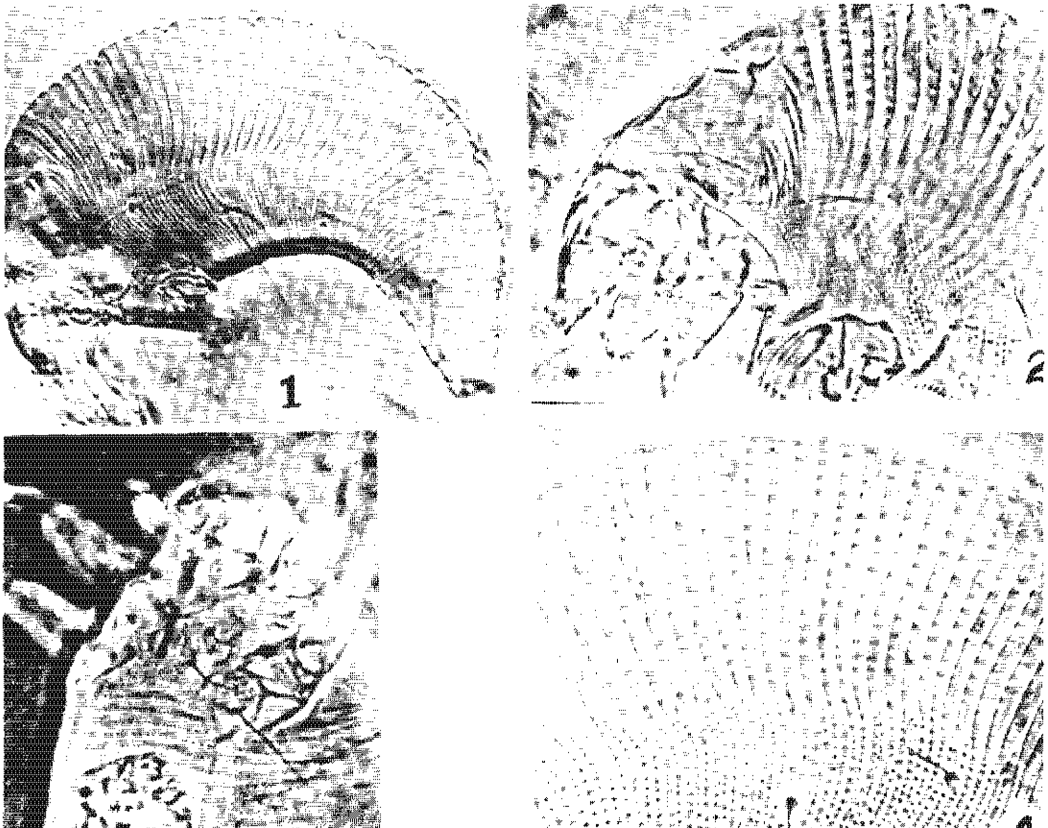


PLATE 25. Fig. 1-6 *Phyllocoptes didelphis* K.

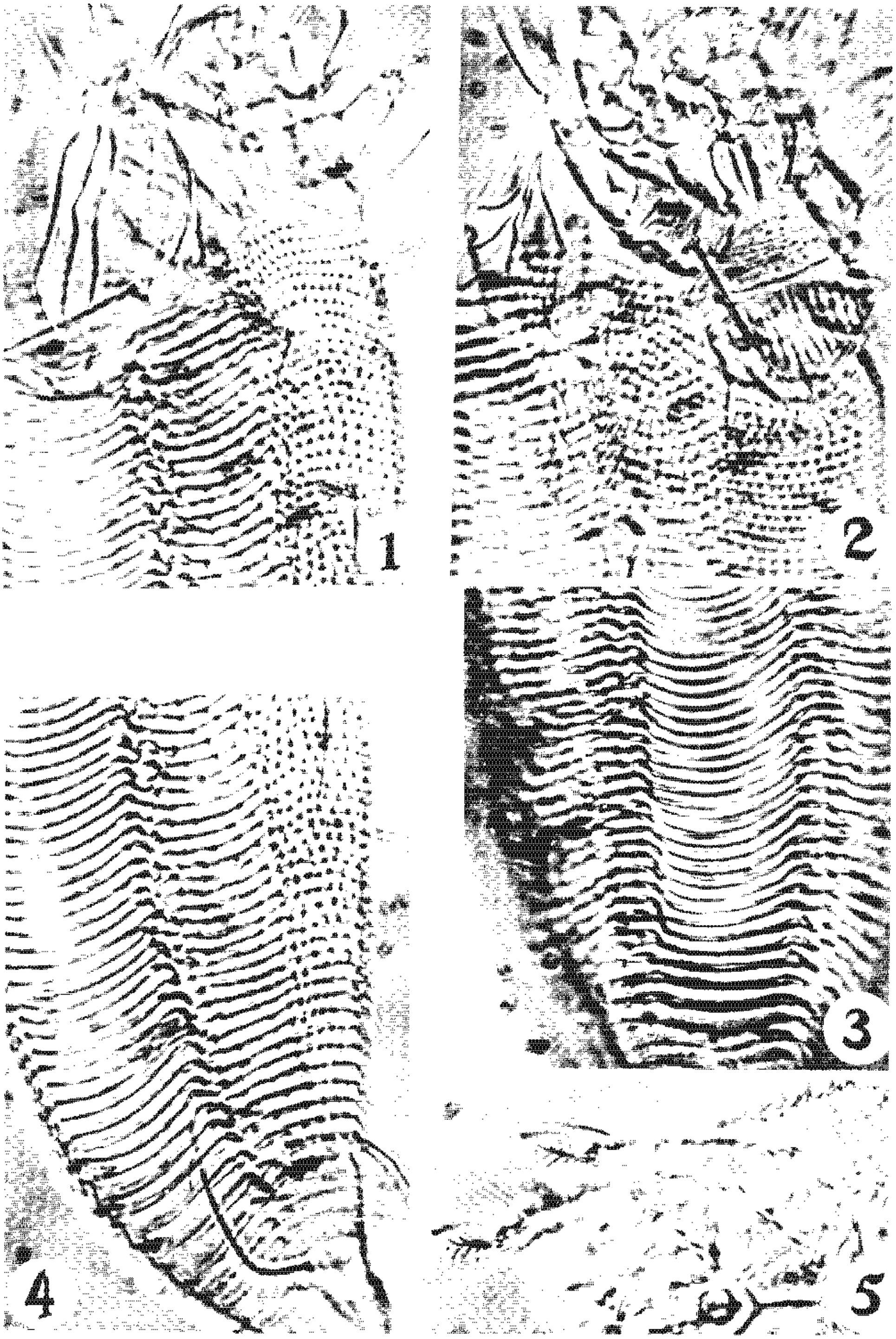


PLATE 26. Fig. 1-5 *Phyllocoptes microspinatus* Hall

PLATE 27. Fig. 1-4 *Phyllocoptes slinkardensii* K.

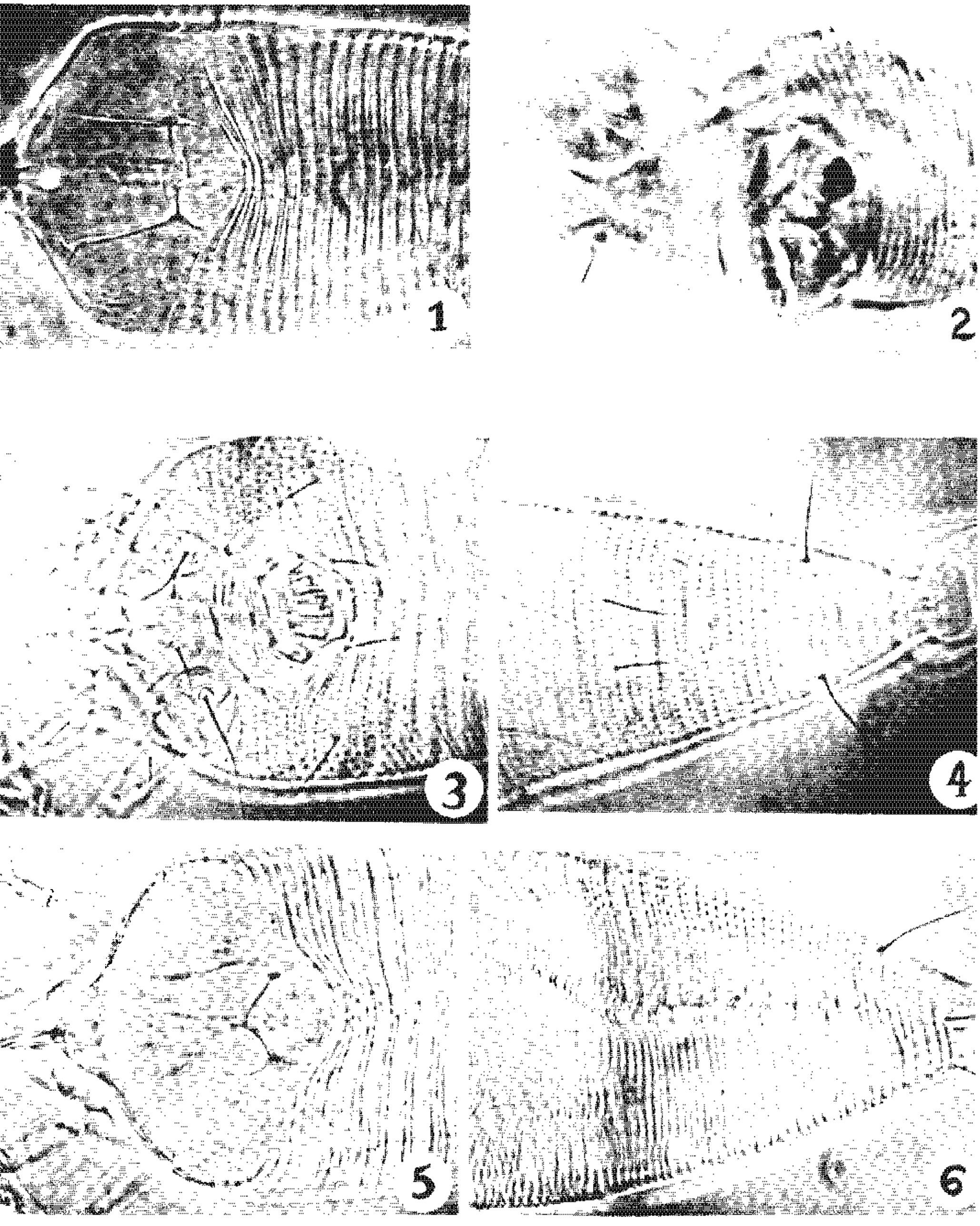


PLATE 28. Fig. 1-2 *Calepitrimerus vitis* (Nalepa); Fig. 3-4 *Calepitrimerus baileyi* (K.).

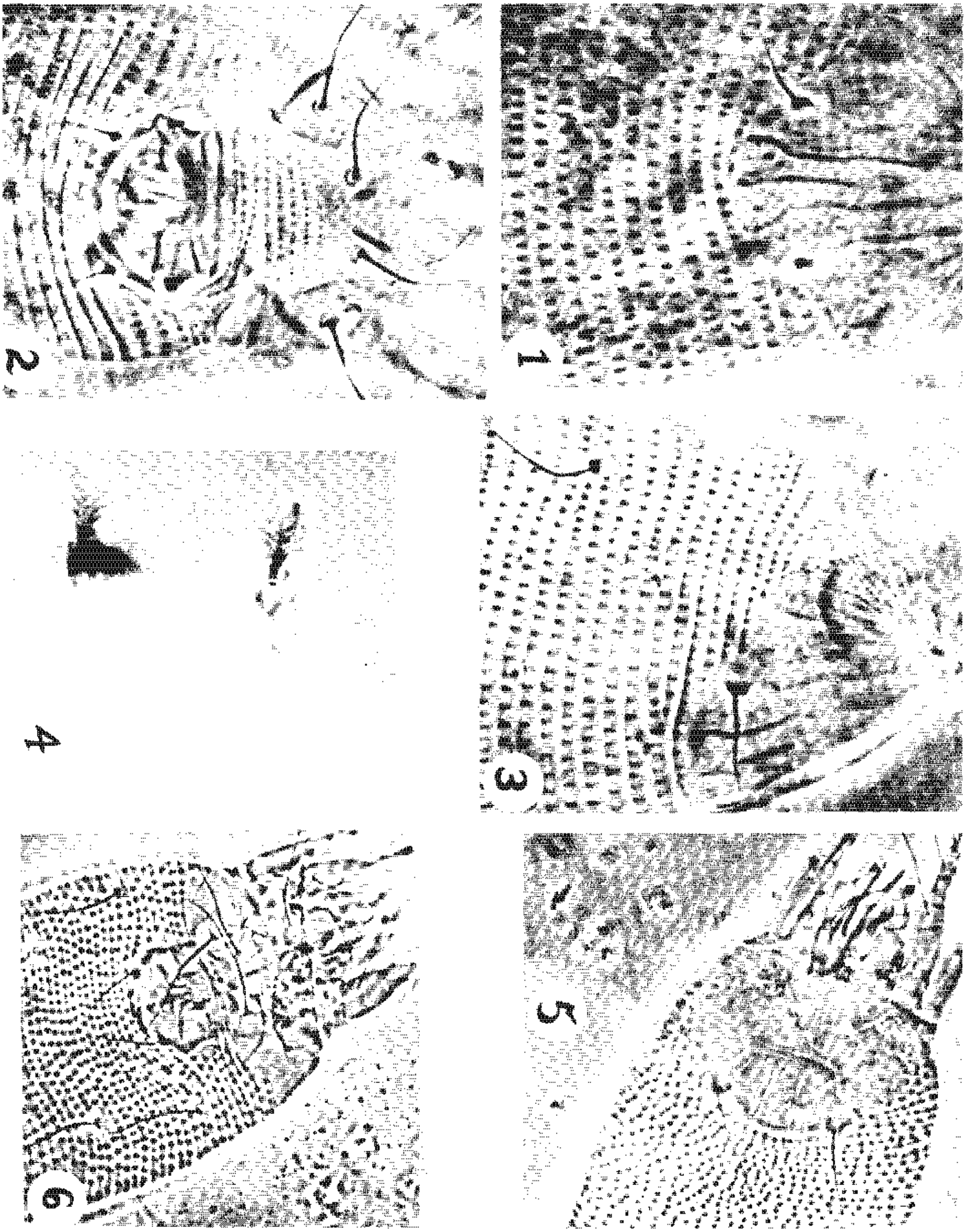


PLATE 29. Fig. 1-4 *Phytoptus brownei* (K.); Fig. 5-6 *Eriophyes calaceris* (K.).

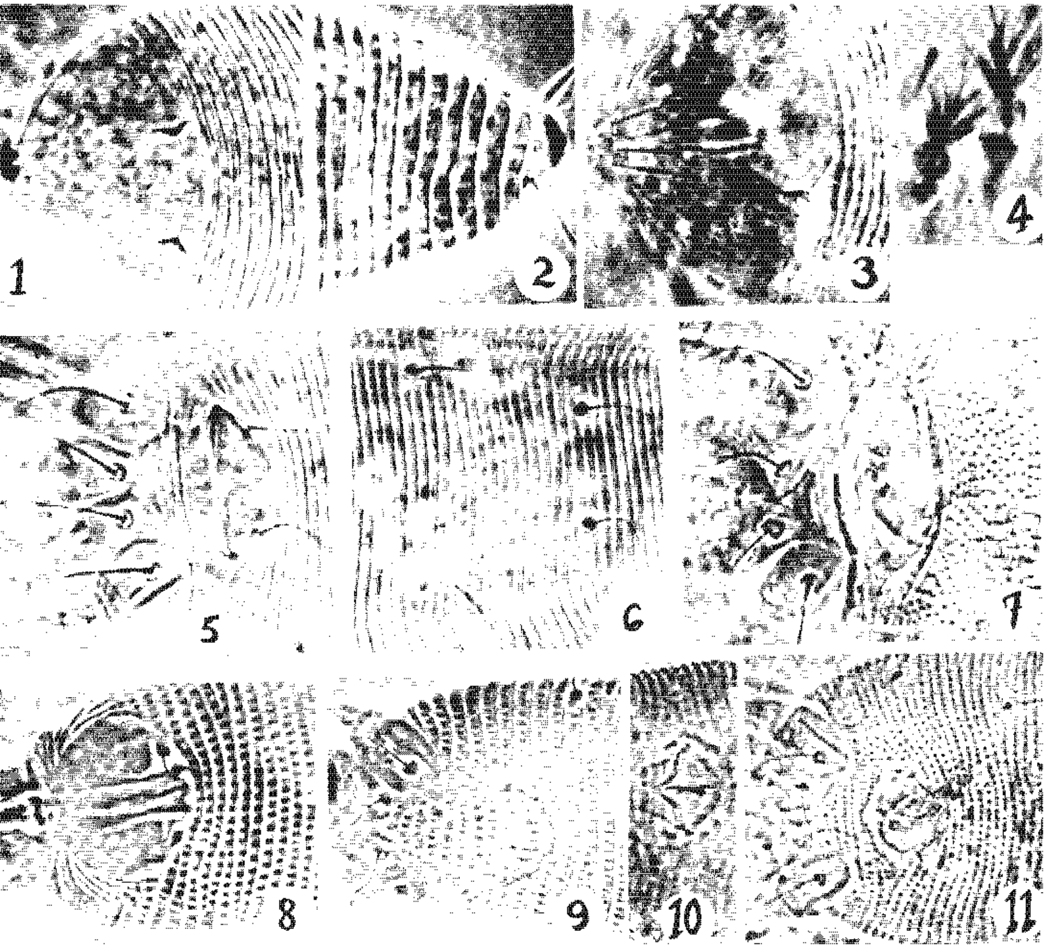


PLATE 30. Fig. 1-7 *Phytoptus emarginatae* (K.); Fig. 8-11 *Phytoptus prunidemissae* (K.).

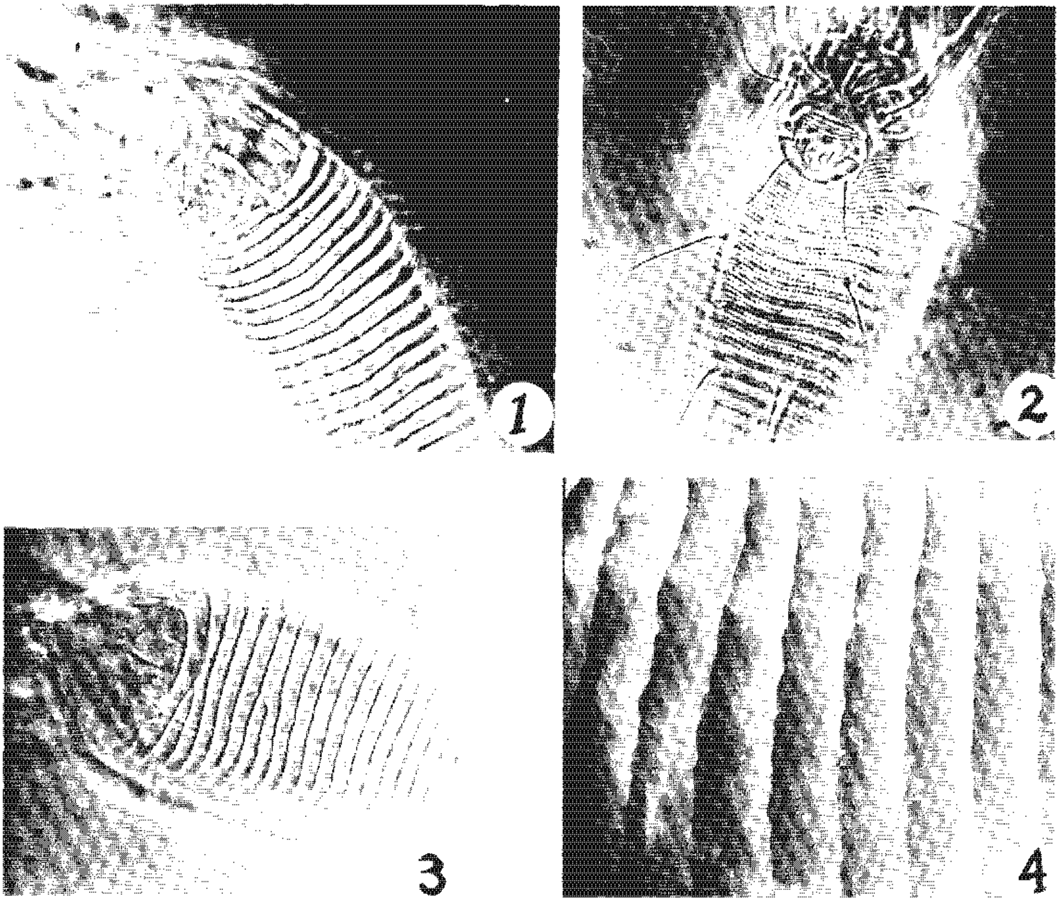


PLATE 31. Fig. 1-4 *Tetra mcdanieli* n. sp.

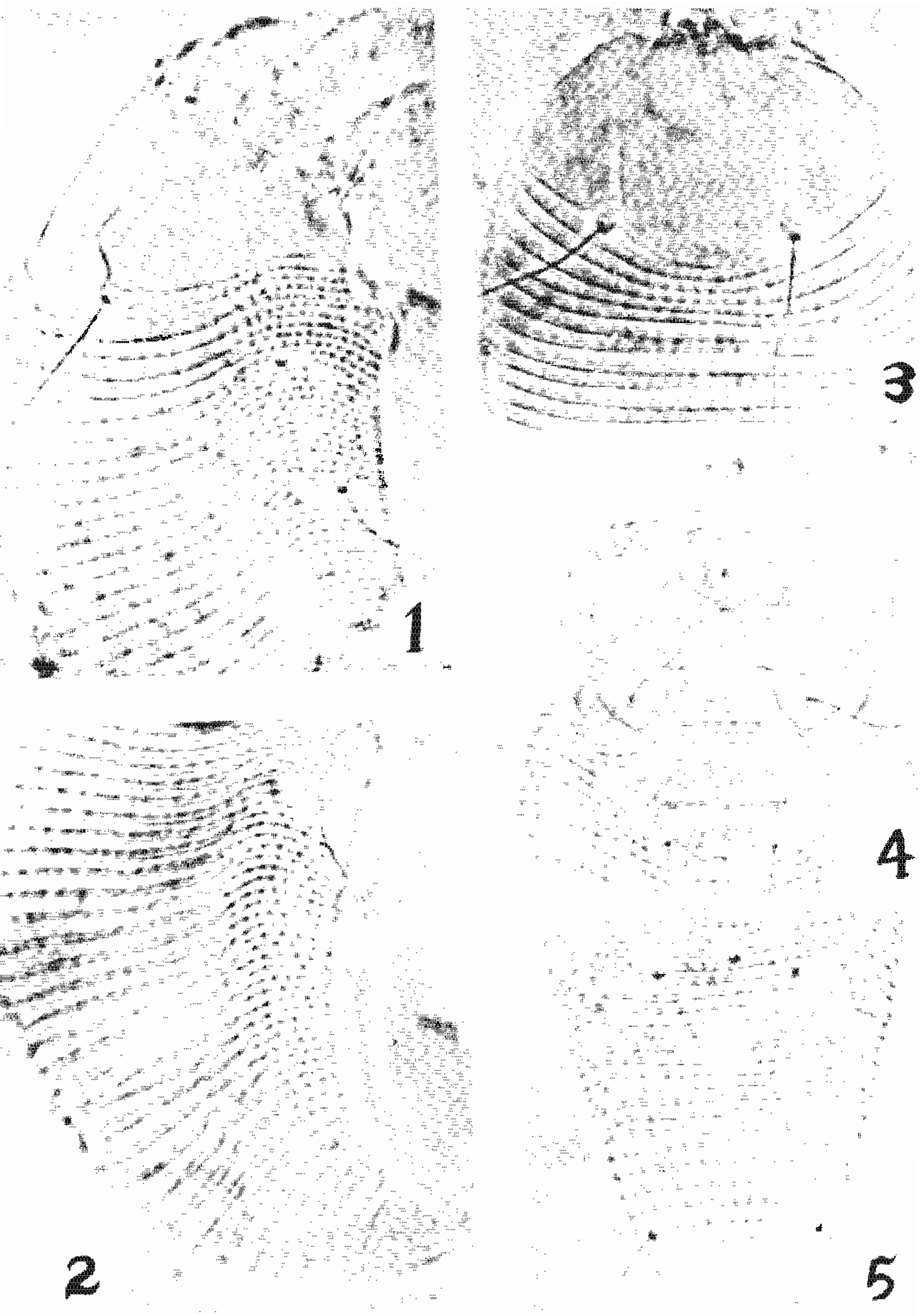


PLATE 32. Fig. 1-5 *Tegonotus aesculifoliae* (K.) deutogyne.

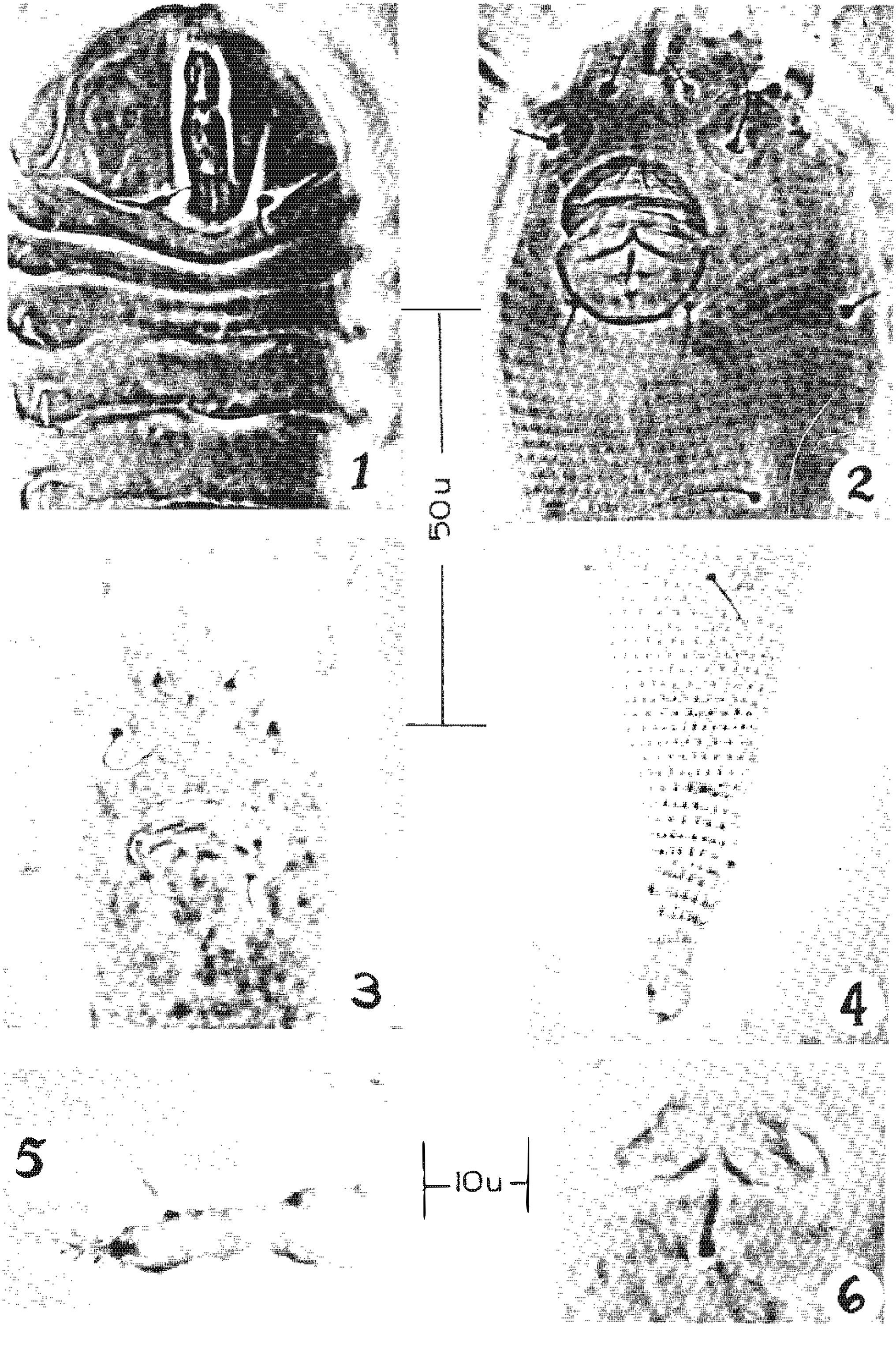


PLATE 33. Fig. 1-6 *Tegonotus lindenus* n. sp.

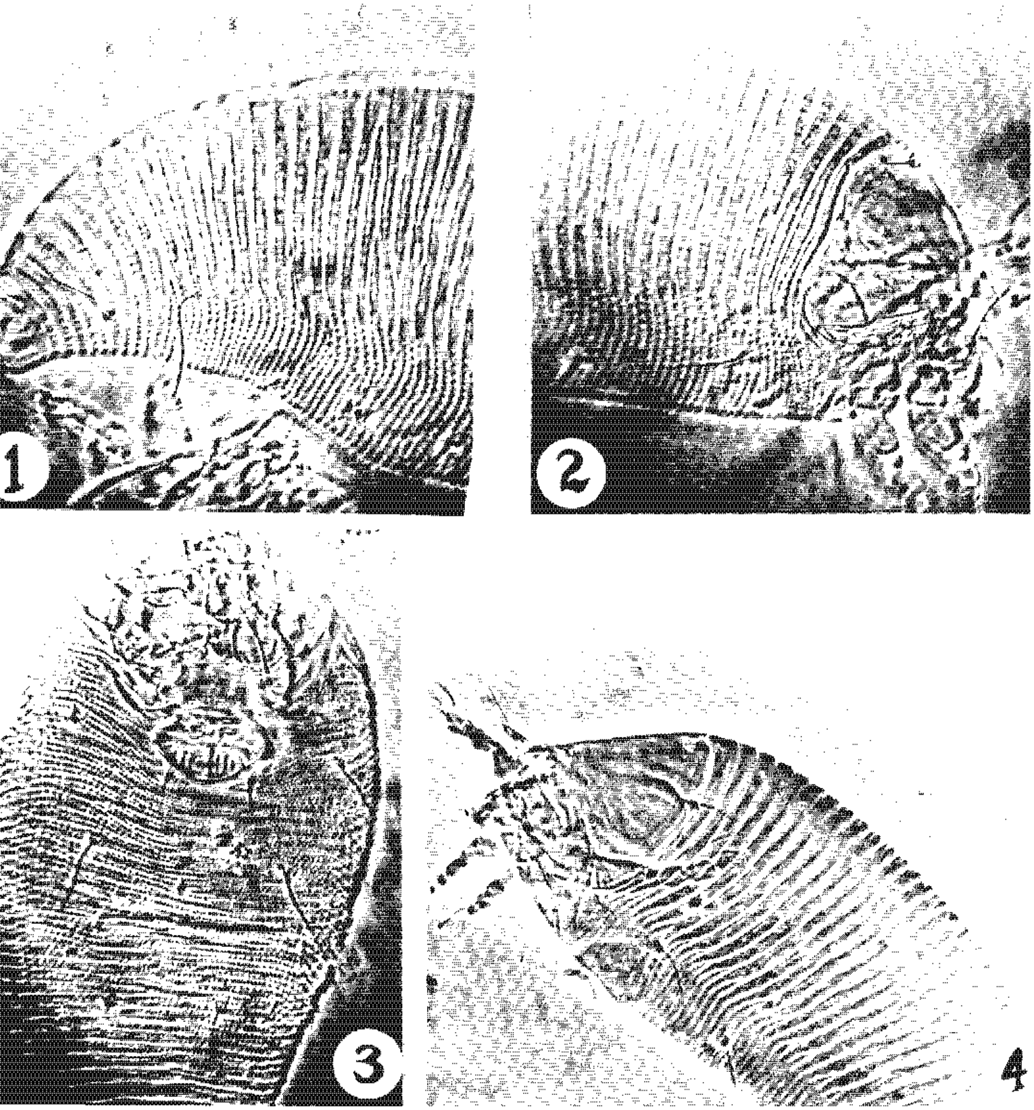


PLATE 34. Fig. 1-4. *Vasates quadripedes* Shimer.

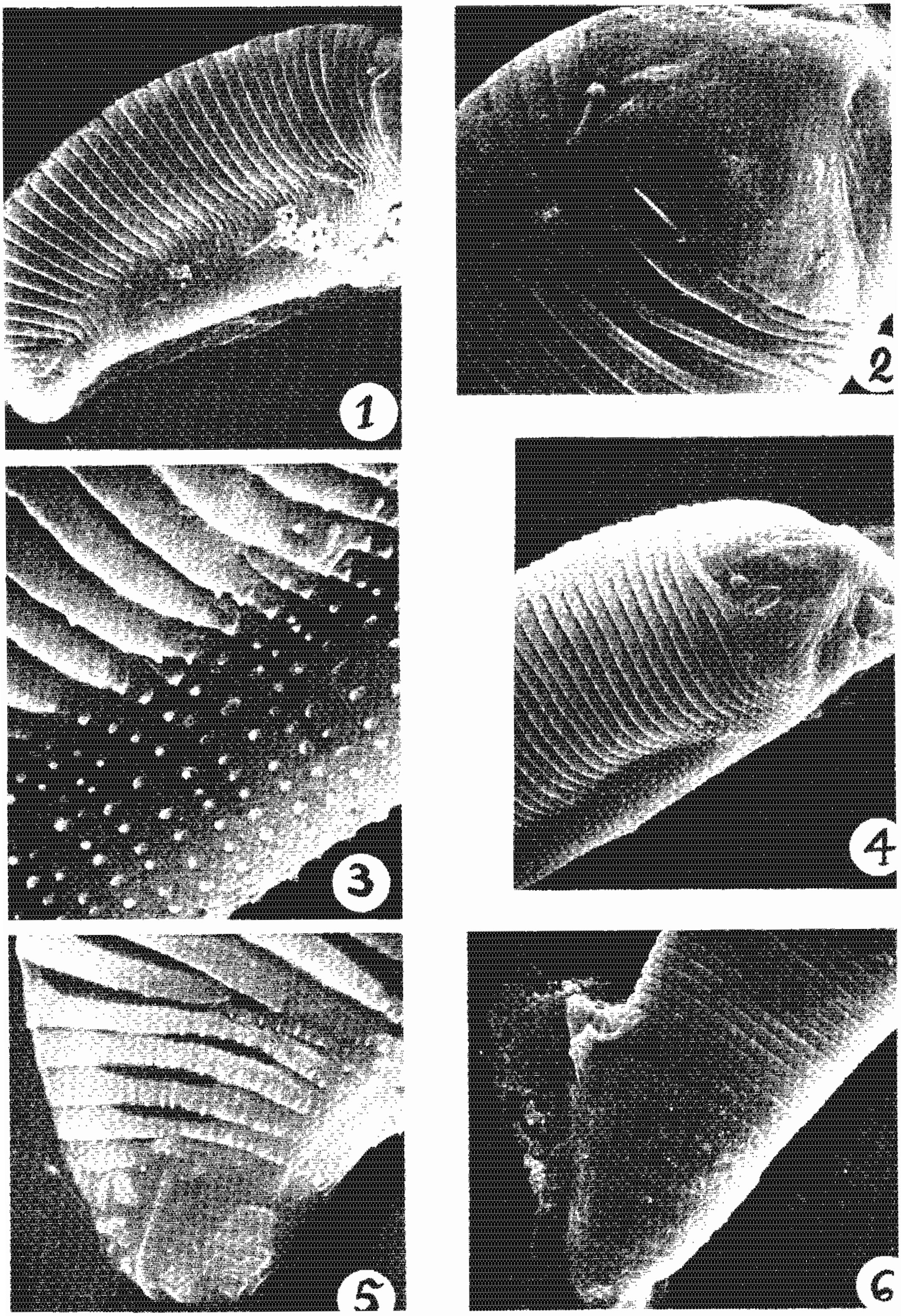


PLATE 35. Fig. 1-6. Scanning electron micrographs of *Vasates quadripedes* Shimer.

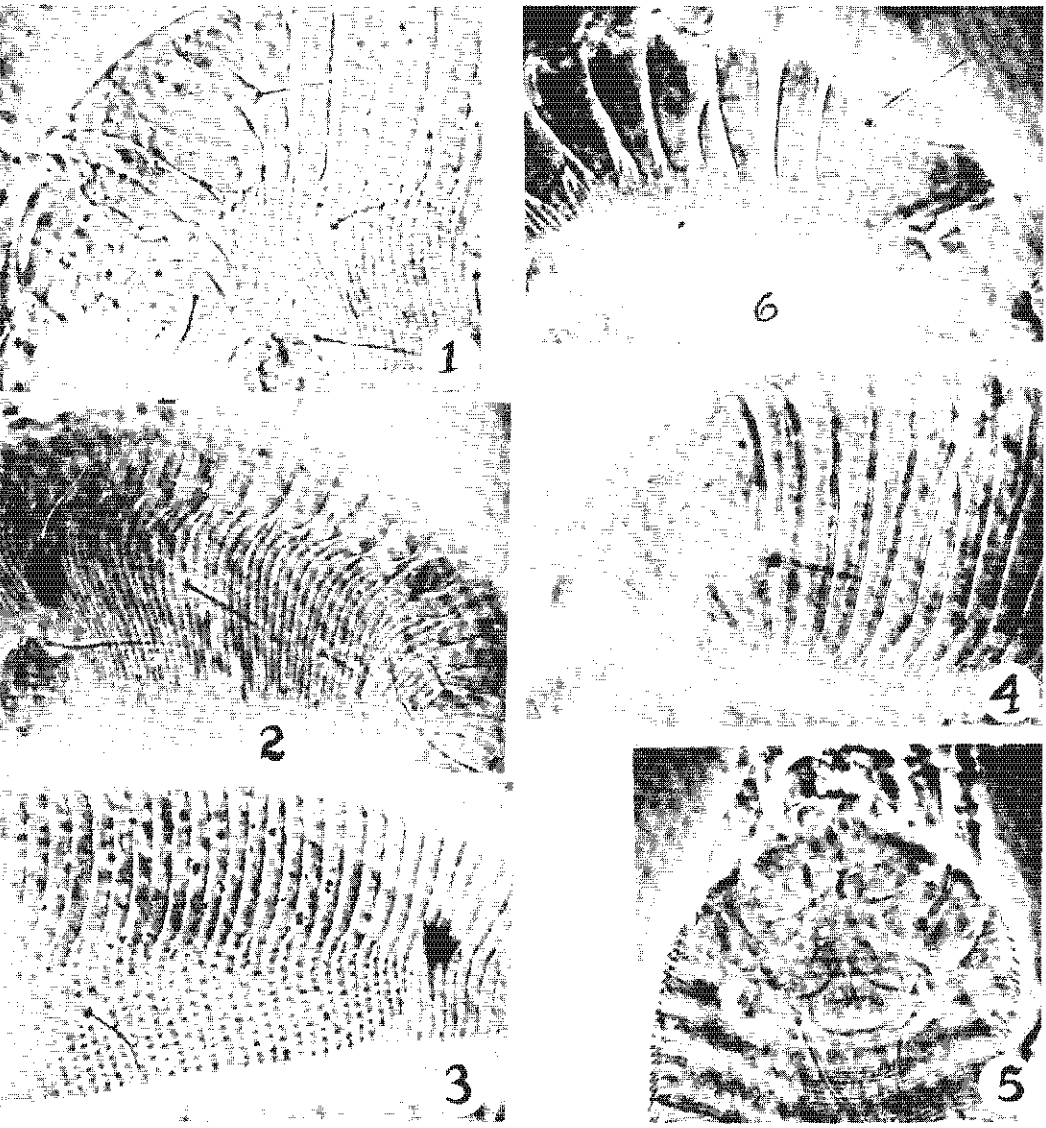


PLATE 36. Fig. 1-5. *Vasates gleditsiae* K.; Fig. 6. *Anthocoptes bakeri* K.

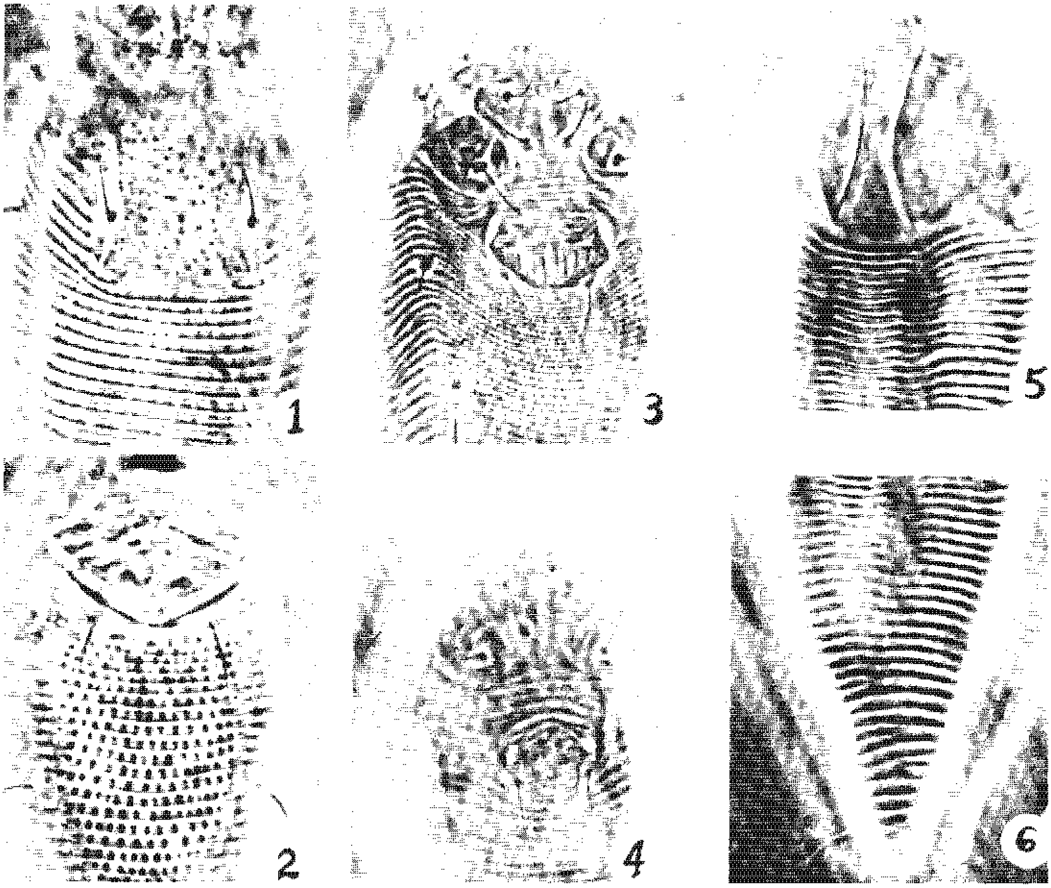


PLATE 37. Fig. 5-6. *Platyphytoptus sabiniana* K. ; Fig. 1-4. *Mesolox tuttlei* K.

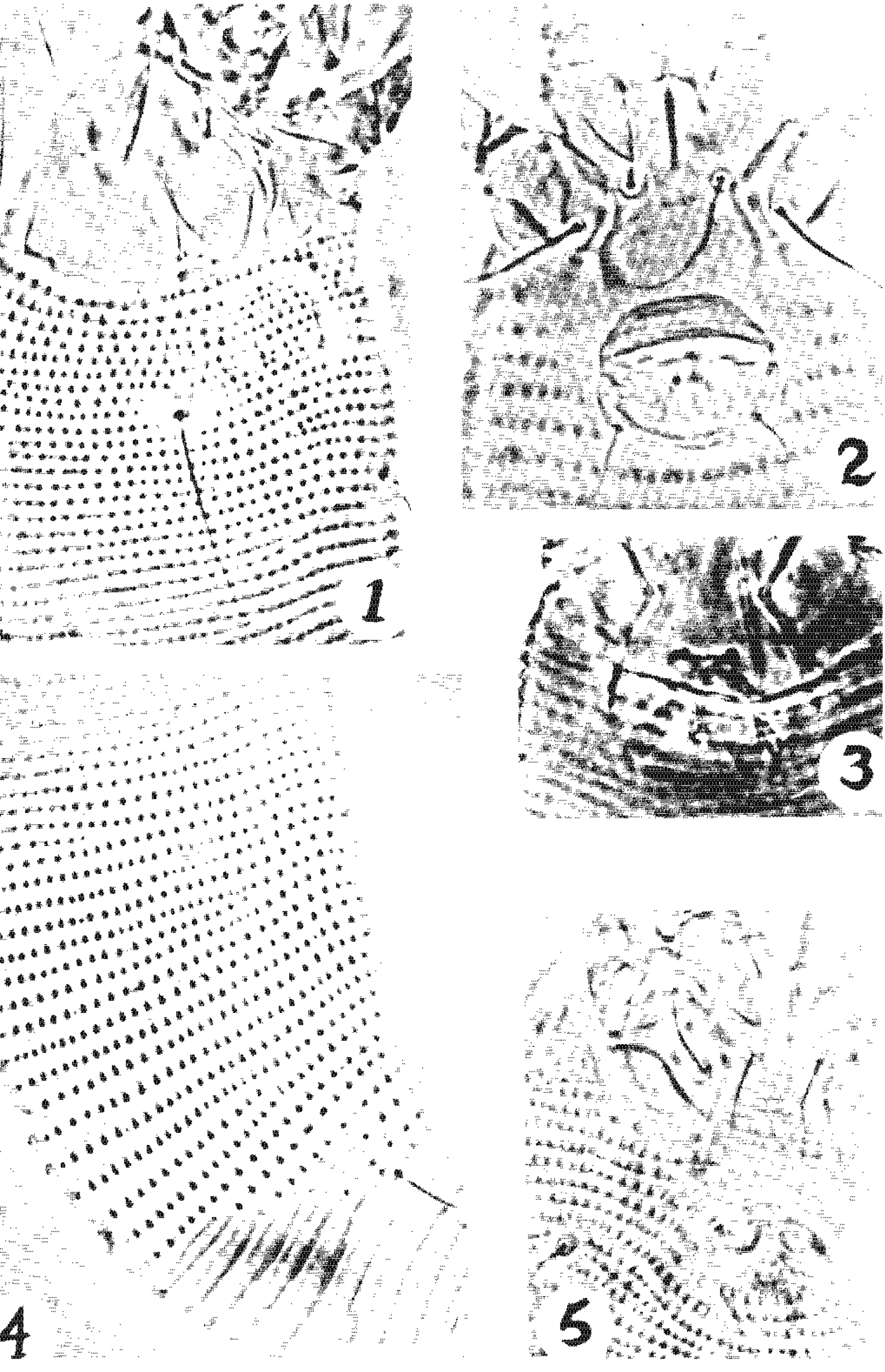


PLATE 38. Fig. 1-5. *Phytocoptella rotundus* (Hall)

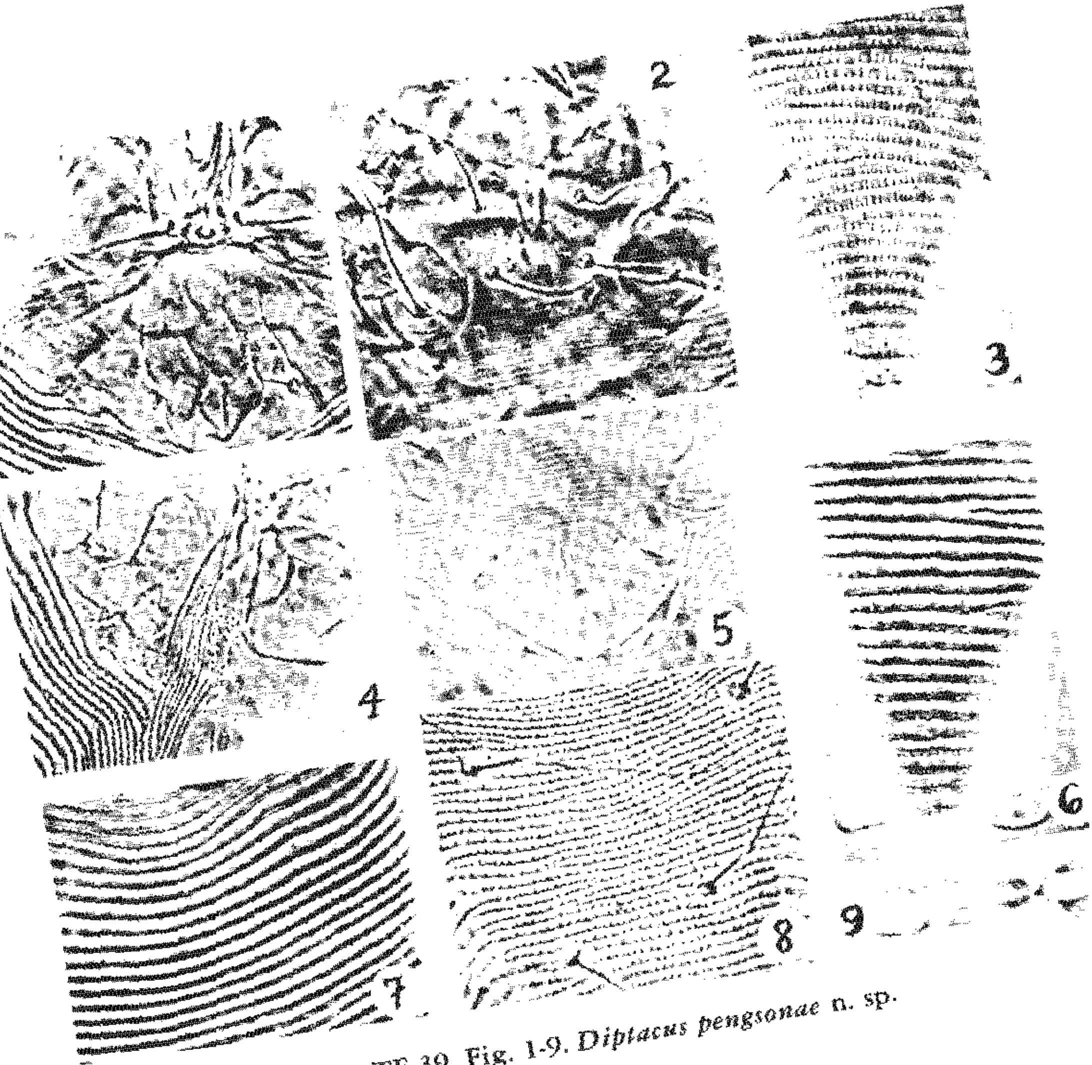


PLATE 39. Fig. 1-9. *Diplacus pengsonae* n. sp.

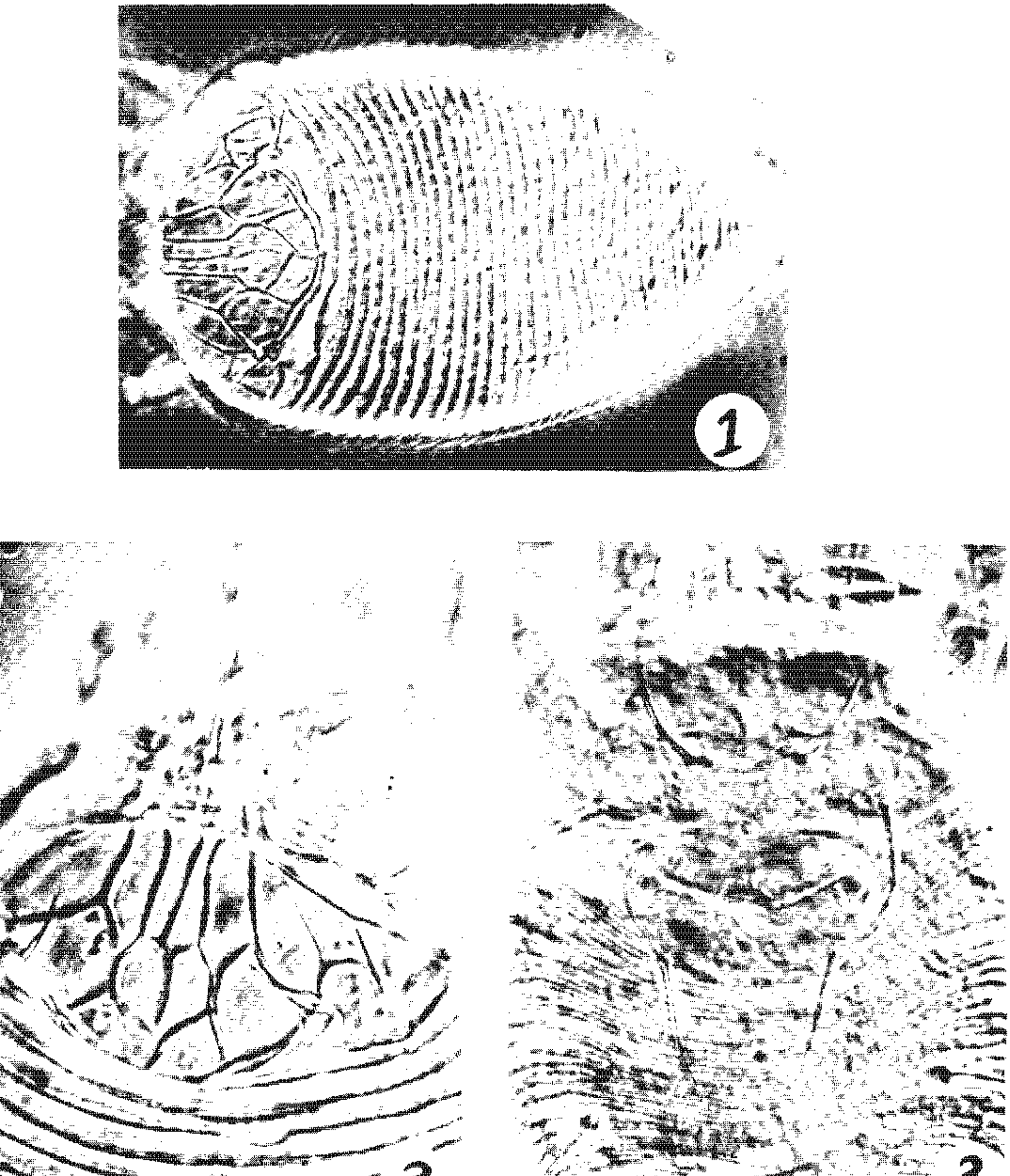


PLATE 40. Fig. 1-3. *Rhyncaphytoptus atlanticus* K.

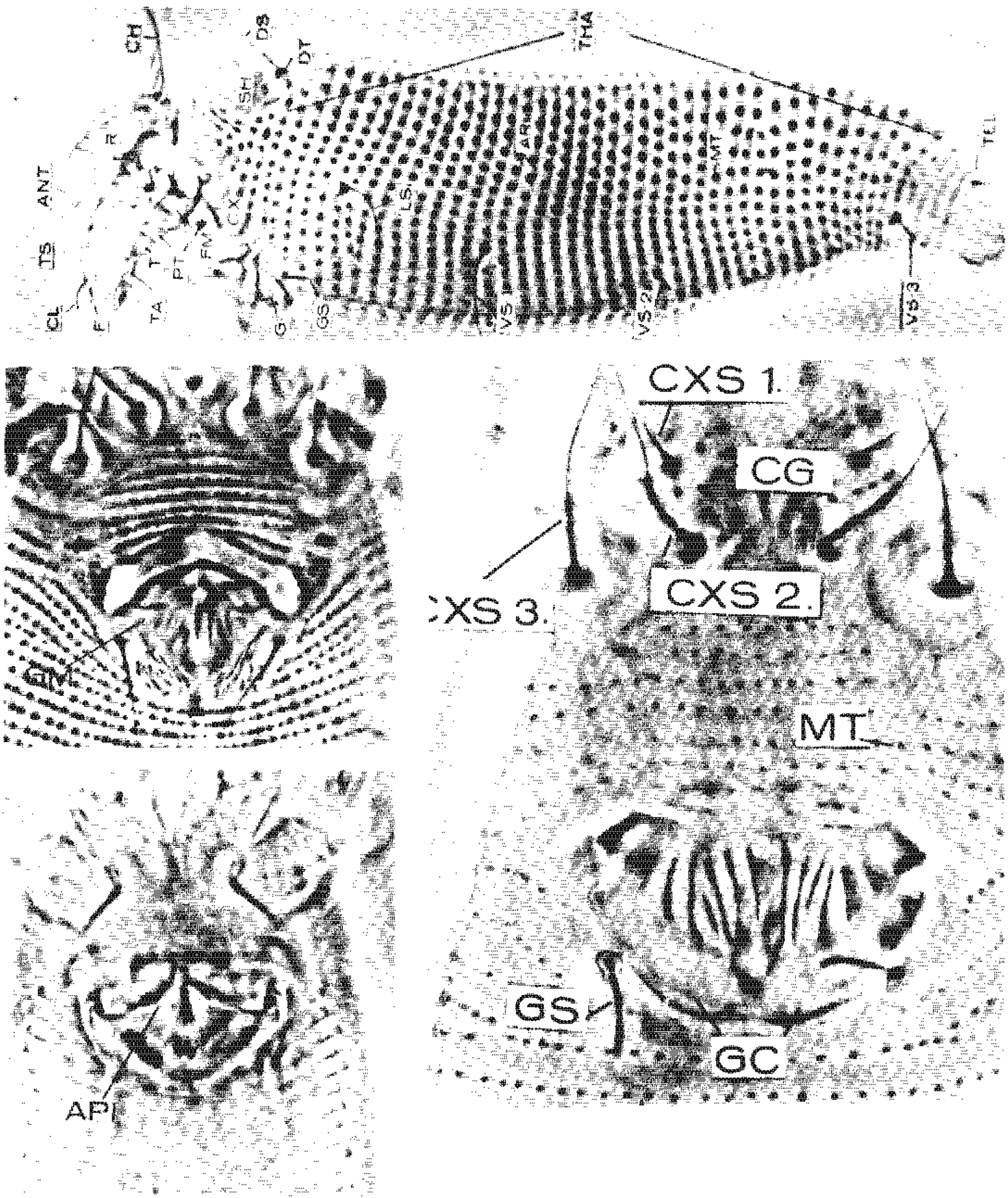


PLATE 41. External anatomy of an eriophyoid mite to identify the structures referred to in the description and plates.

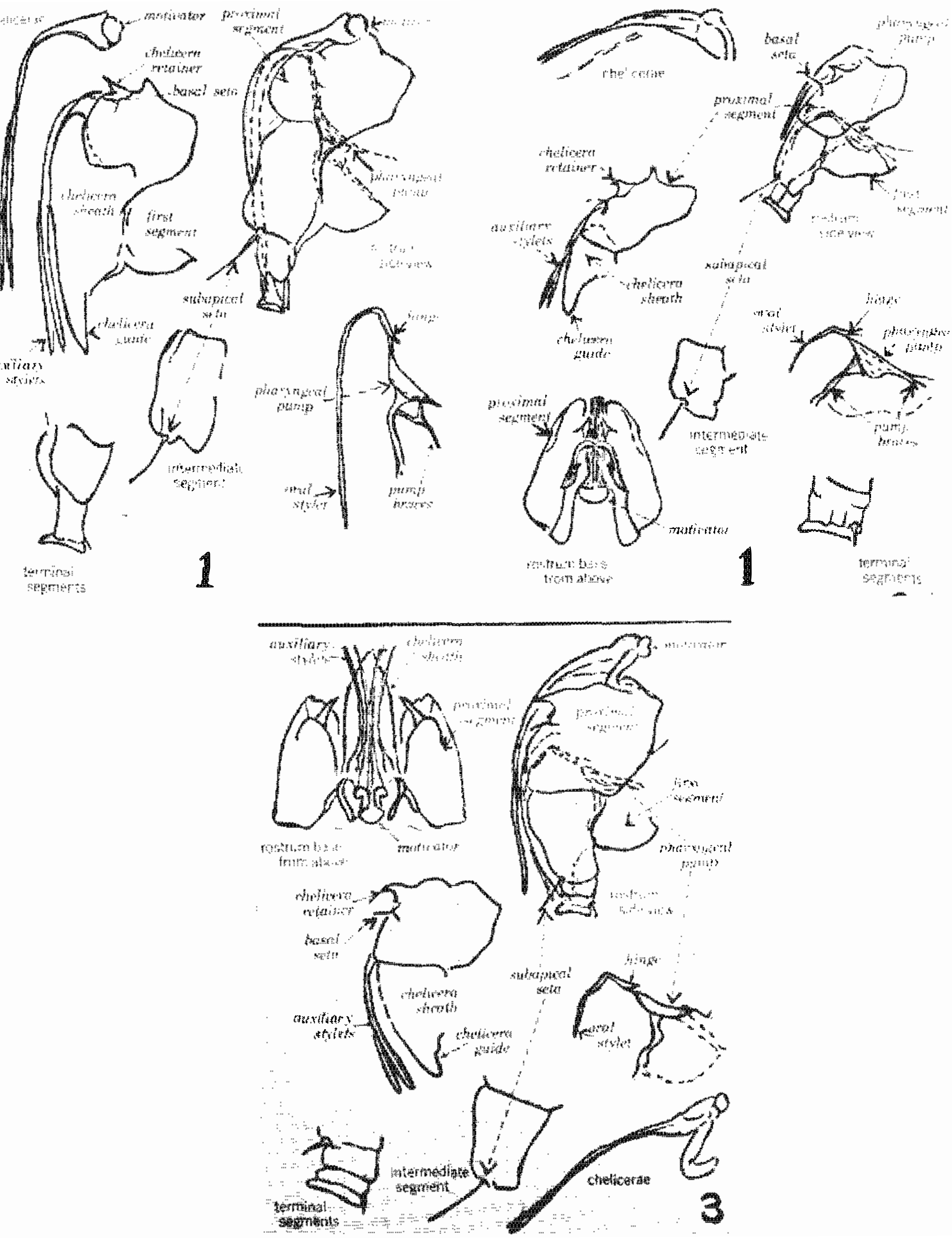


PLATE 42. Fig. 1-3. Mouth Parts of the Eriophyoid Mite. (After Keifer). 1, *Diptacus gigantorhynthus* (Nal.). 2, *Eriophyes ligustri* (K.). 3, *Calacarus carinatus* (Greene).

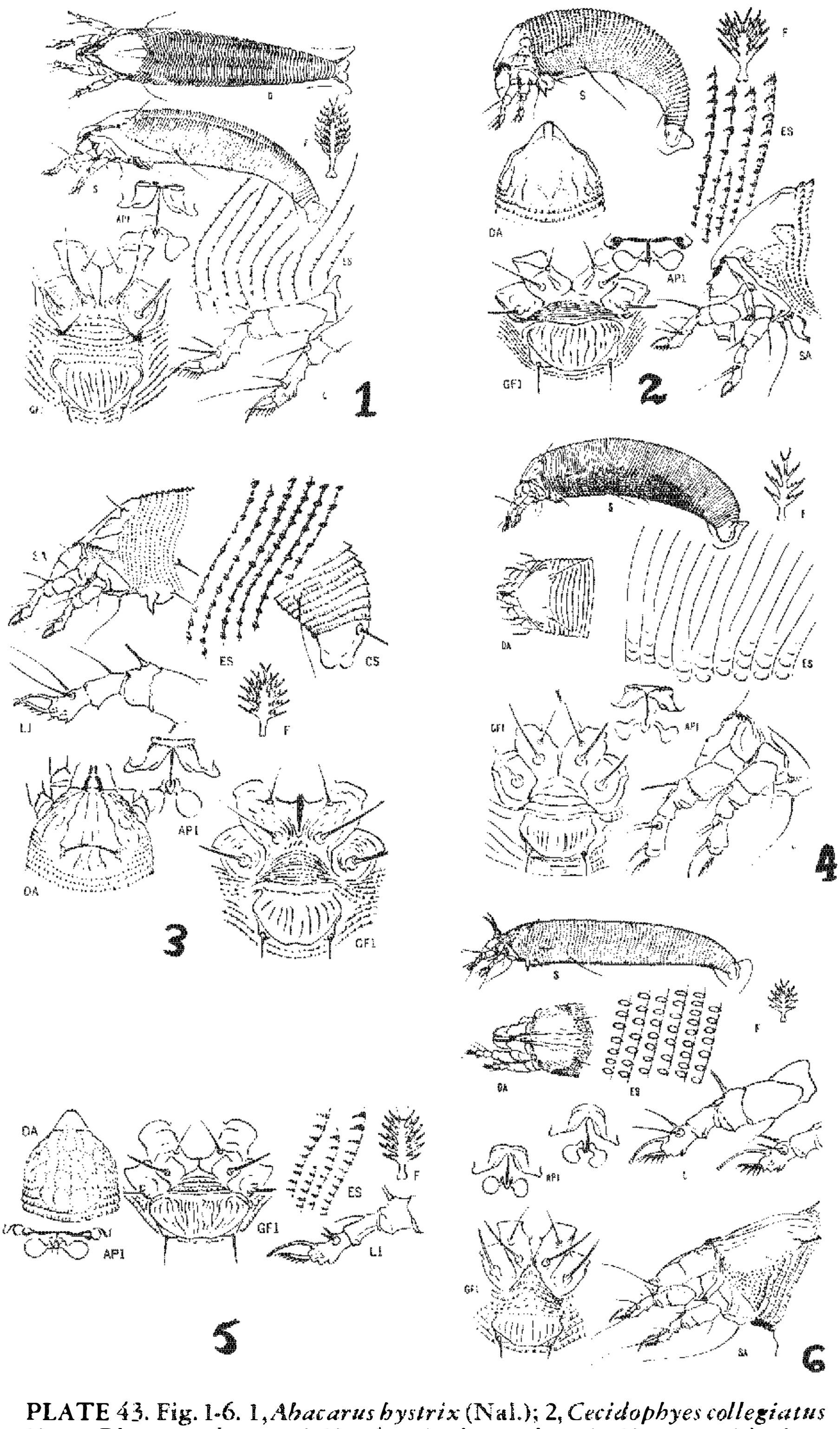


PLATE 43. Fig. 1-6. 1, *Abacarus hystrix* (Nal.); 2, *Cecidophyes collegiatus* K.); 3, *Phytoptus brownei* (K.); 4, *Eriophyes calaceris* (K.); 5, *Cecidophyes pusilla* (K.); 6, *Eriophyes mori* (K.).

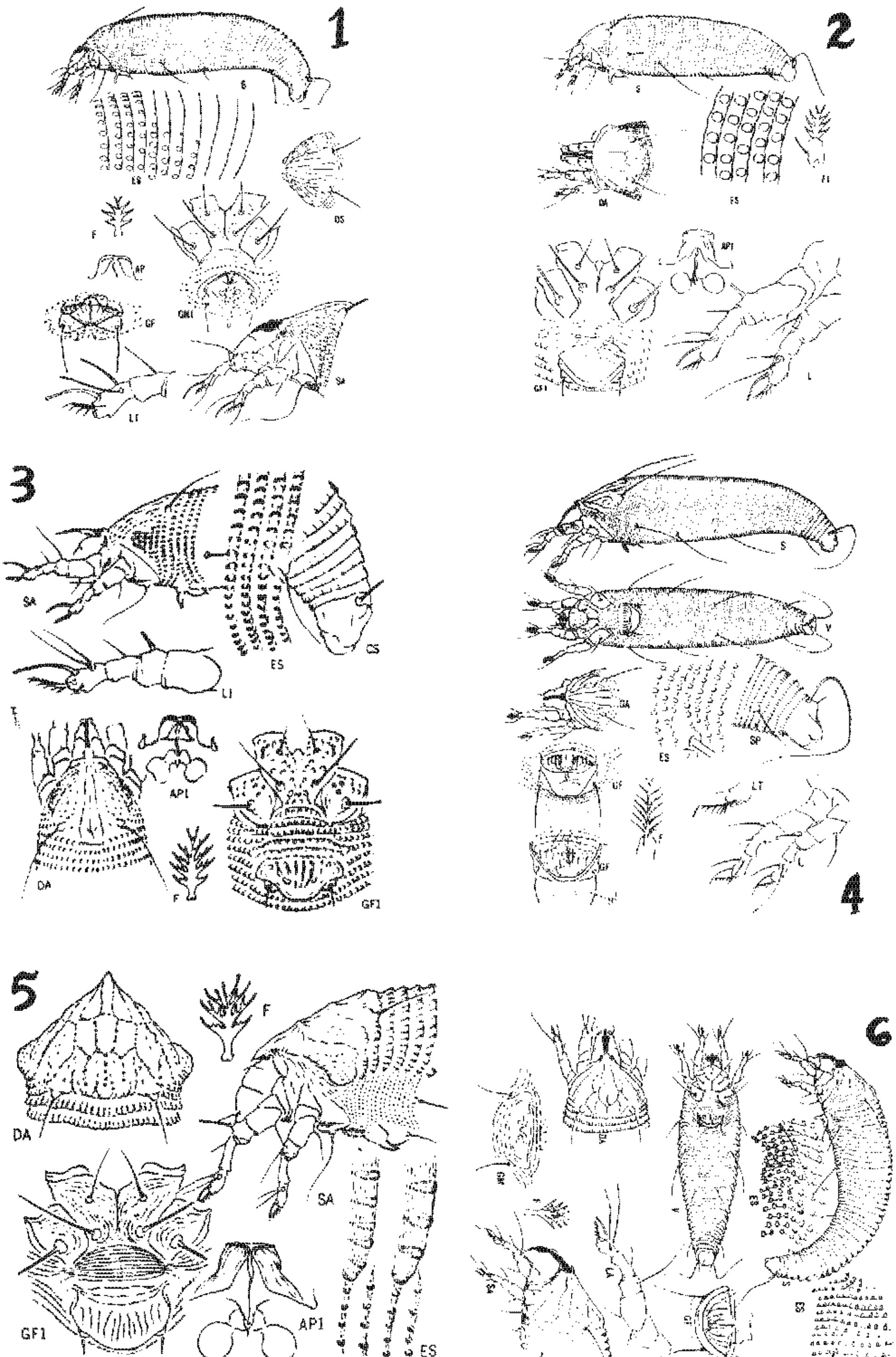


PLATE 44. Fig. 1-6. 1, *Eriophyes neoartemisiae* (K.); 2, *Eriophyes parapopuli* (K.); 3, *Eriophyes parulmi* (K.); 4, *Eriophyes tulipae* (K.); 5, *Aculops lobuliferus* (K.); 6, *Aculops toxicophagus* (Ewing).

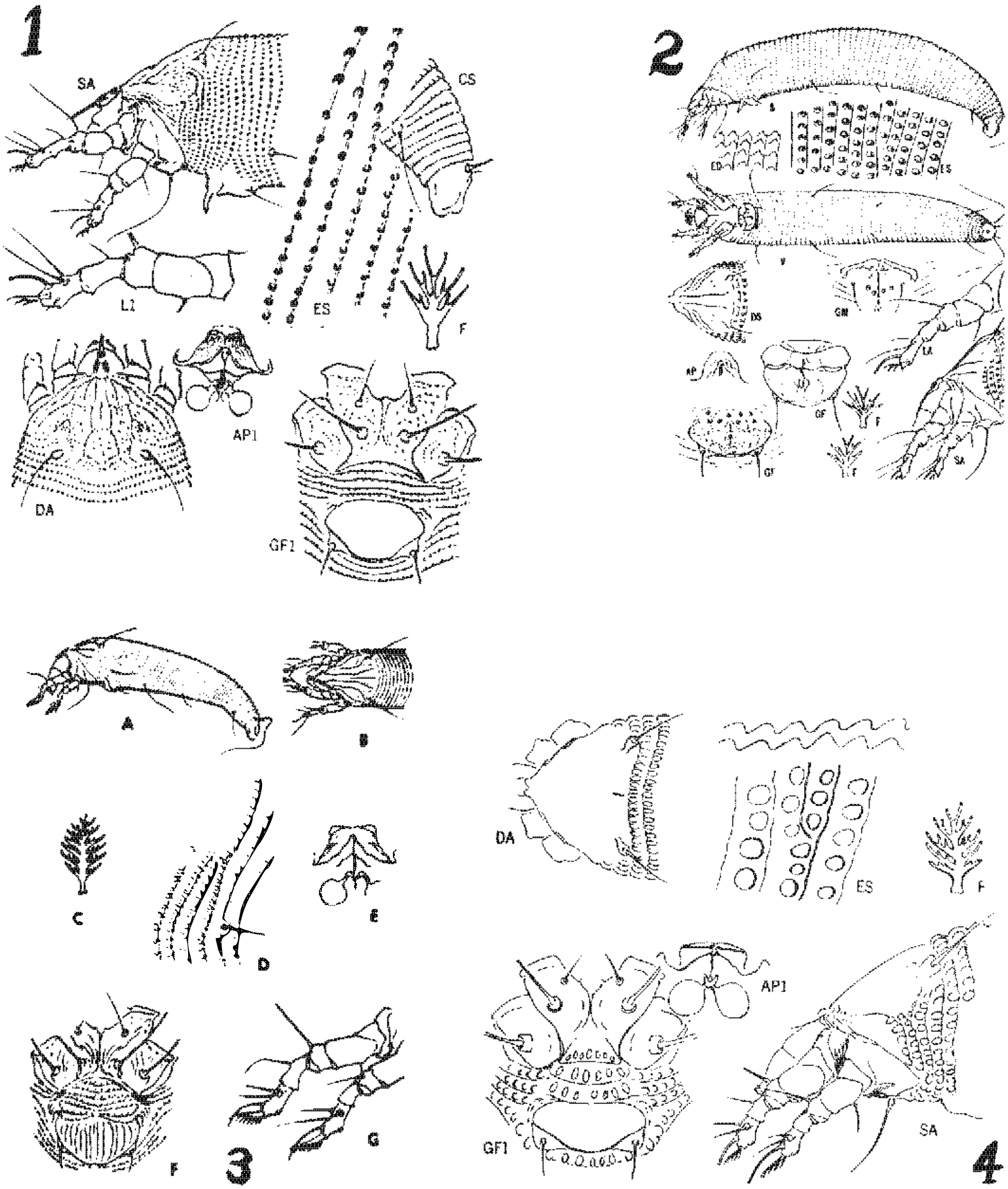
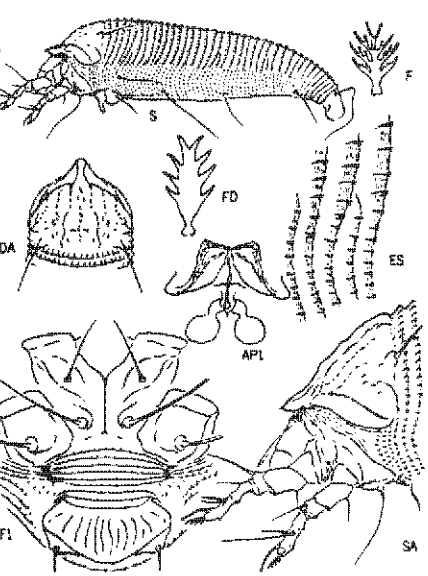


PLATE 45. Fig. 1-4. 1, *Eriophyes chondriphora* (K.); 2, *Eriophyes mackiei* (K.); 3, *Aculodes mckenzie* (K.); 4, *Eriophyes celtis* Ken.

PLATE 46. Fig. 1-5. 1, *Aculus nigrus* K. ; 2, *Aculus cornutus* (Banks); 3, *Aculus schlectendali* (Nal.); 4 *Phyllocoptes didelphis* (K.); 5, *Phyllocoptes microspinatus* Hall; 6, *Phyllocoptes silicis* K.

1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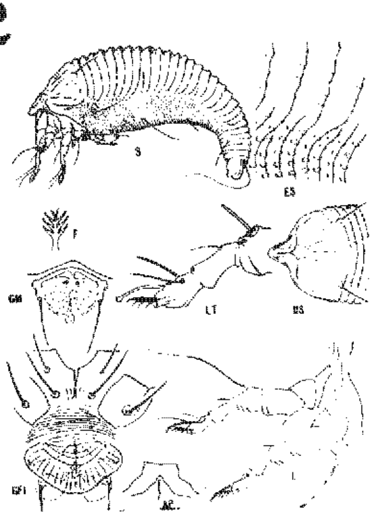
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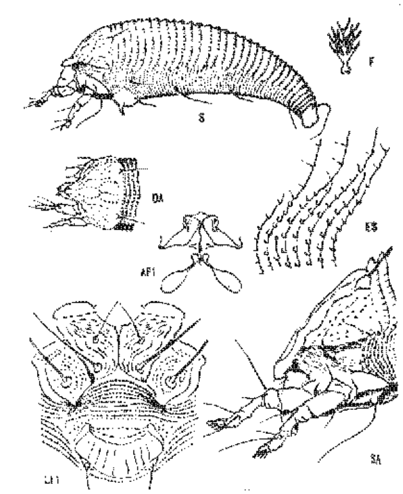
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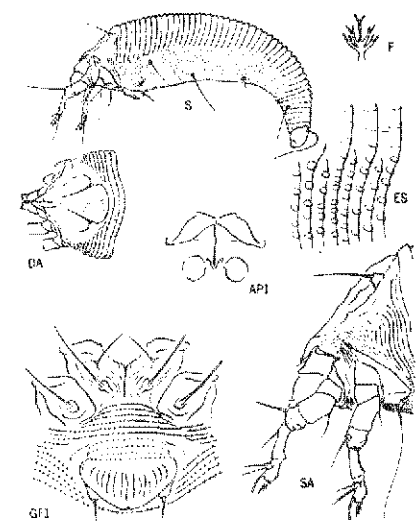
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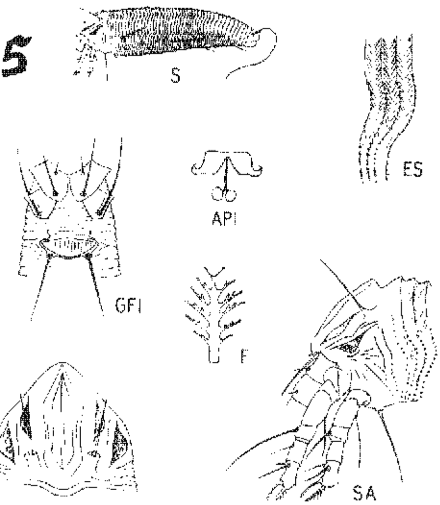
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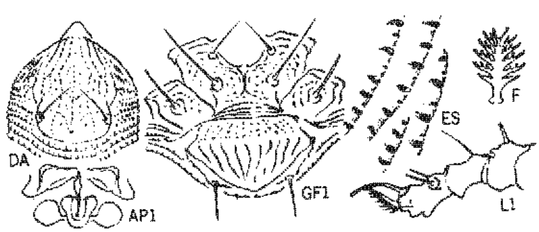
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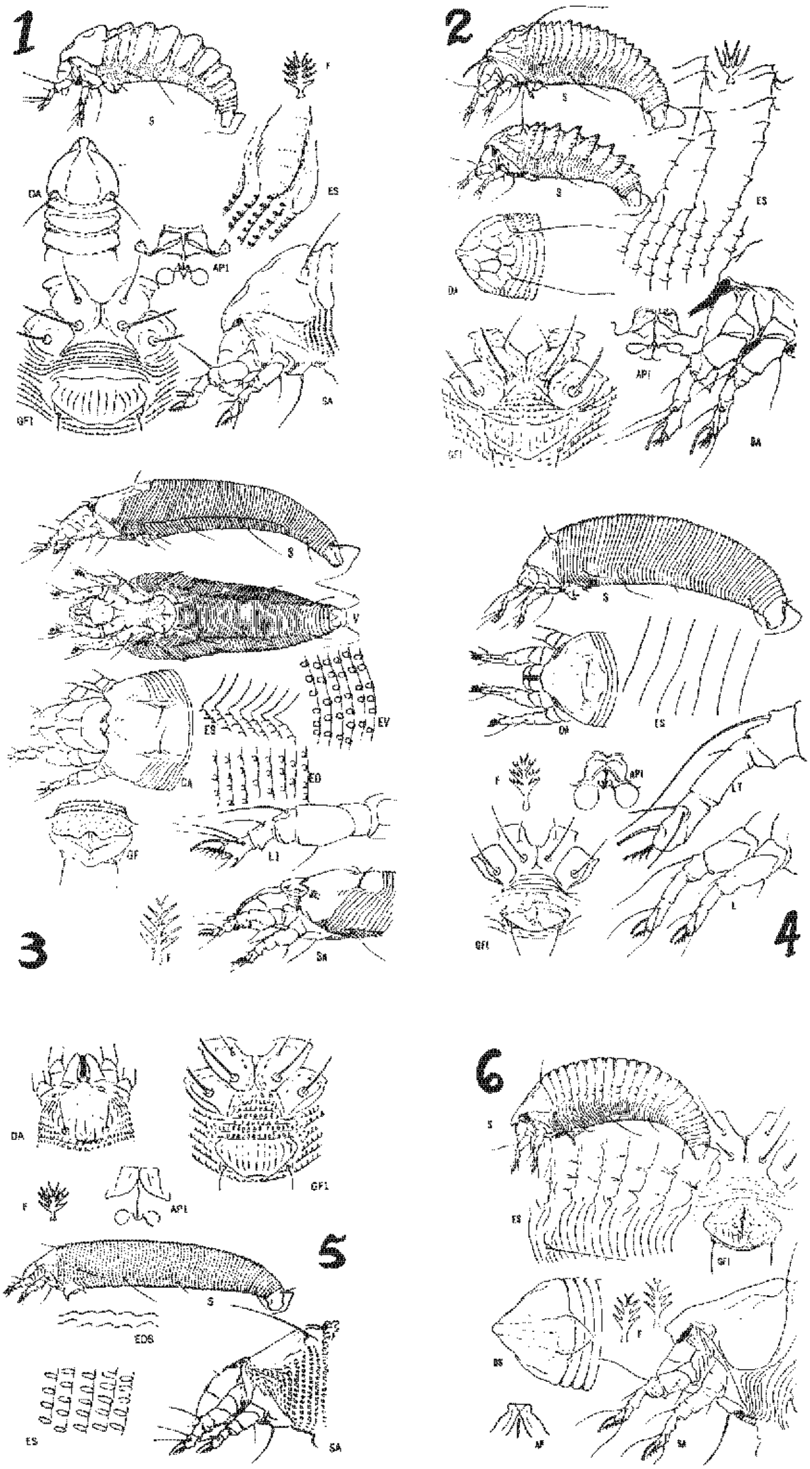


PLATE 47. Fig. 1-6. *Anthocoptes bakeri* K. ; 2, *Anthocoptes punctidorsa* K. ; 3, *Platyphytoptus sabiniana* K. ; 4, *Phytoptus emarginatae* (K.); 5, *Phytoptus prunidemissae* (K.); 6, *Tegonotus aesculifoliae* (K.).

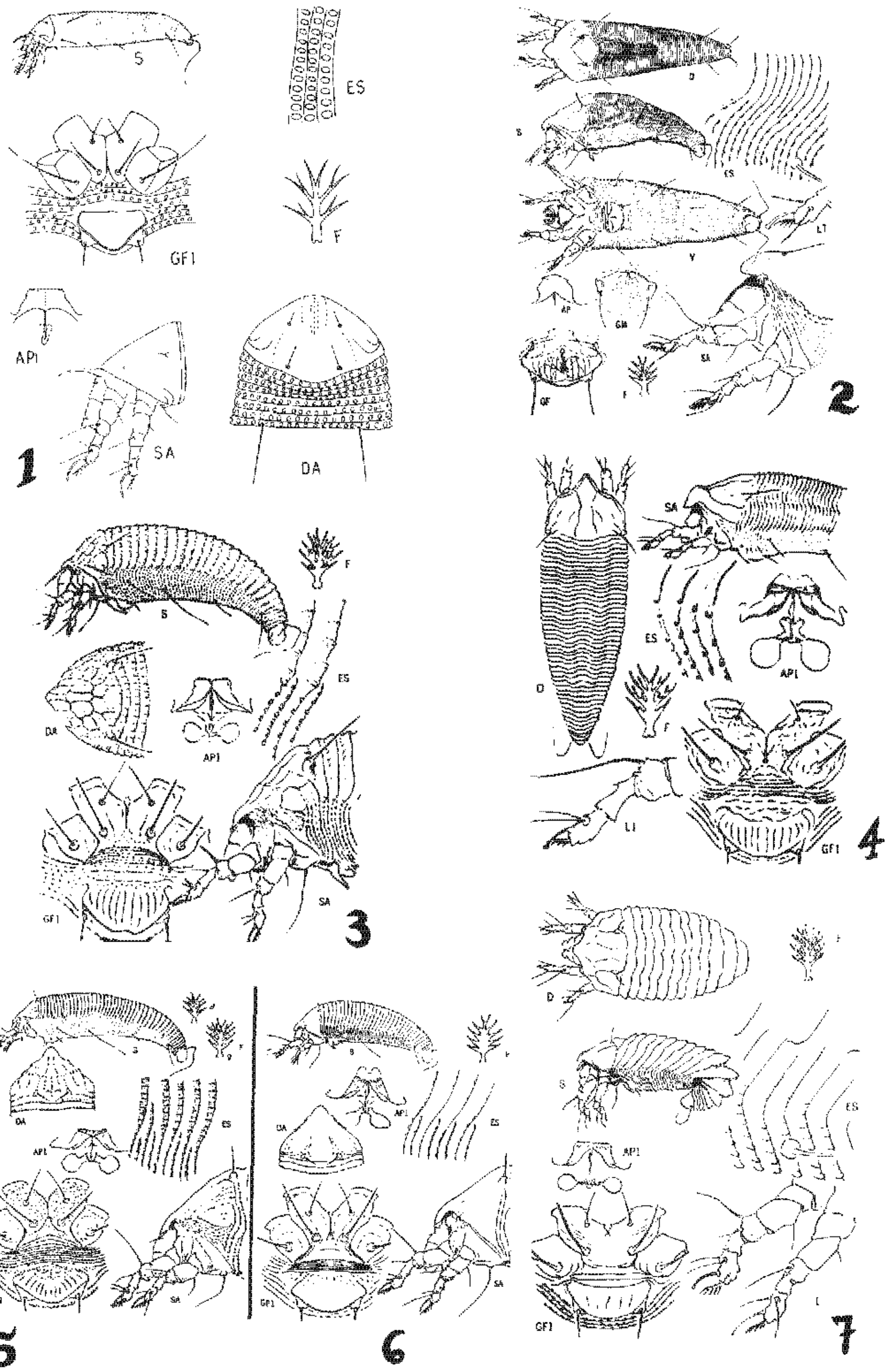


PLATE 48. Fig. 1-7. 1, *Phytocoptella rotundus* (Hall); 2, *Calepitrimerus baileyi* K. ; 3, *Vasates gleditsiae* K. ; 4, *Mesolox tuttlei* K. ; 5, *Vasates quadripedes* Shimer, protogyne; 6, *Vasates quadripedes* Shimer, deutogyne; 7, *Acarelliptus occidentalis* K.

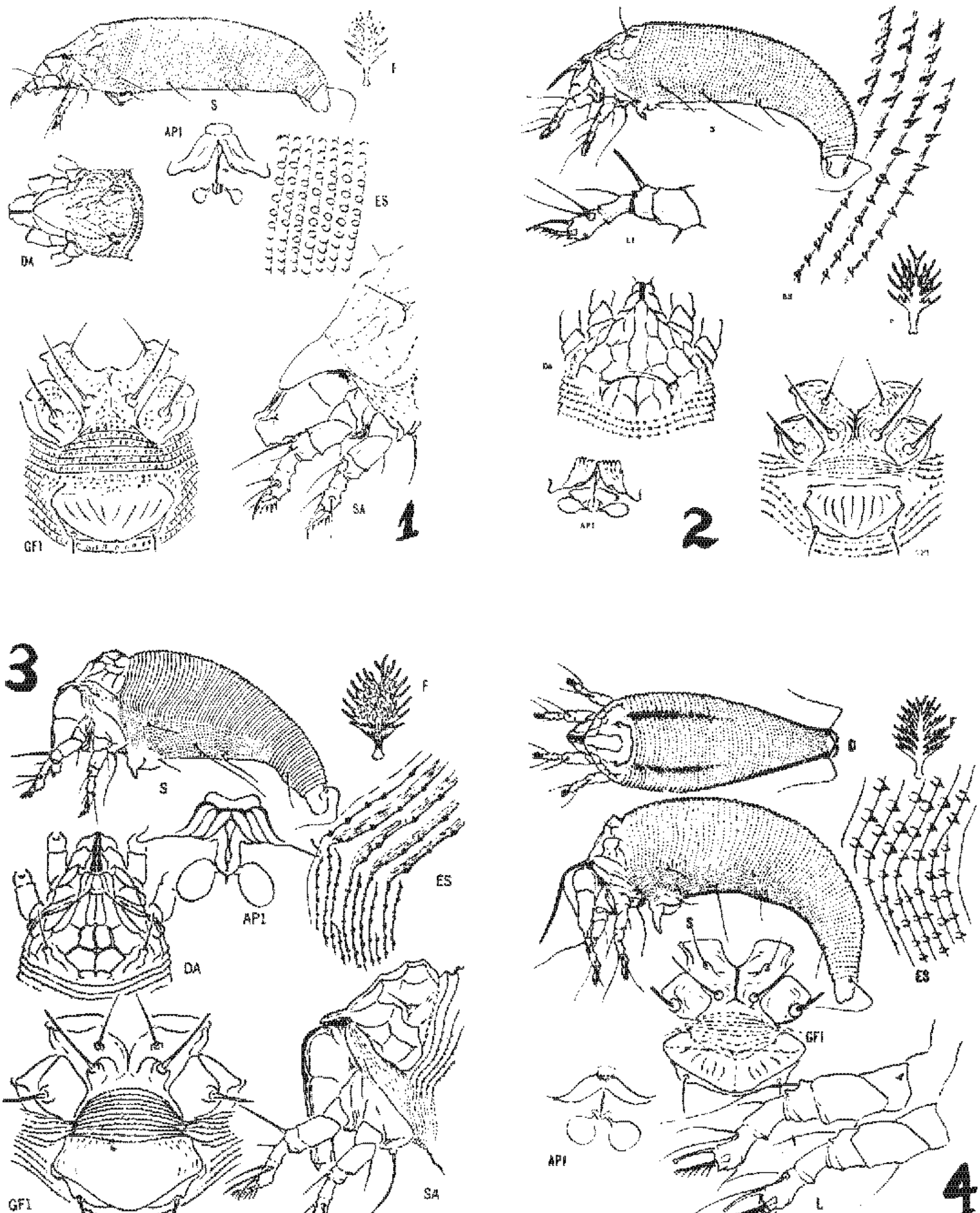
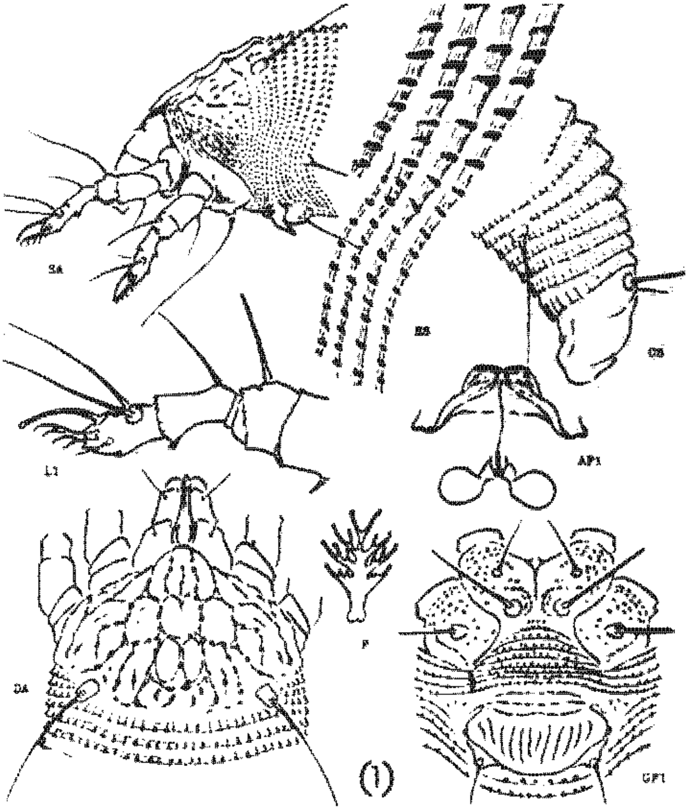


PLATE 49. Fig. 1-4. 1, ***Phyllocoptes arceuthi*** K. ; 2, ***Phyllocoptes slinkardensii*** K ; 3, *Rhyncaphytoptus atlanticus* K. ; 4, *Rhyncaphytoptus strigatus* K.



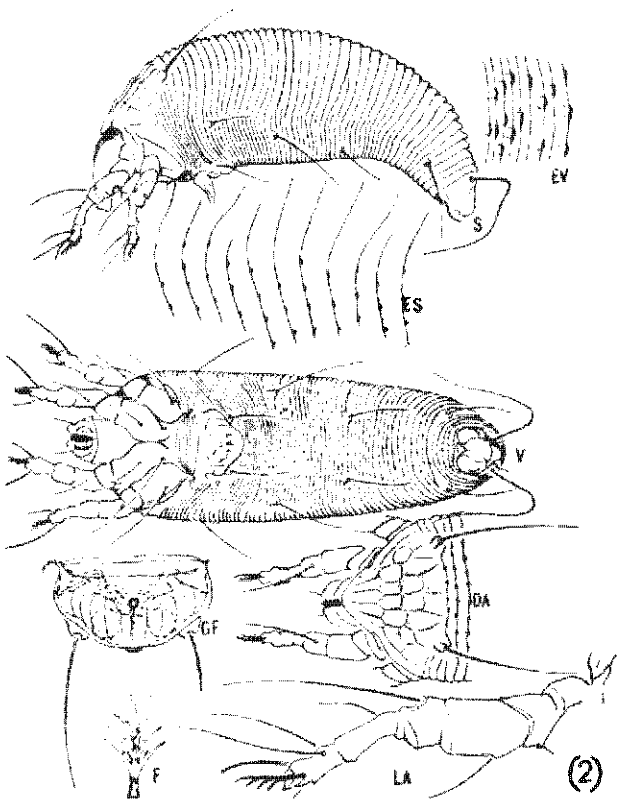


PLATE 50. Fig. 1-2.
1, *Aculus vallis* (K.);
2, *Aculops laevigatae* (Has.)

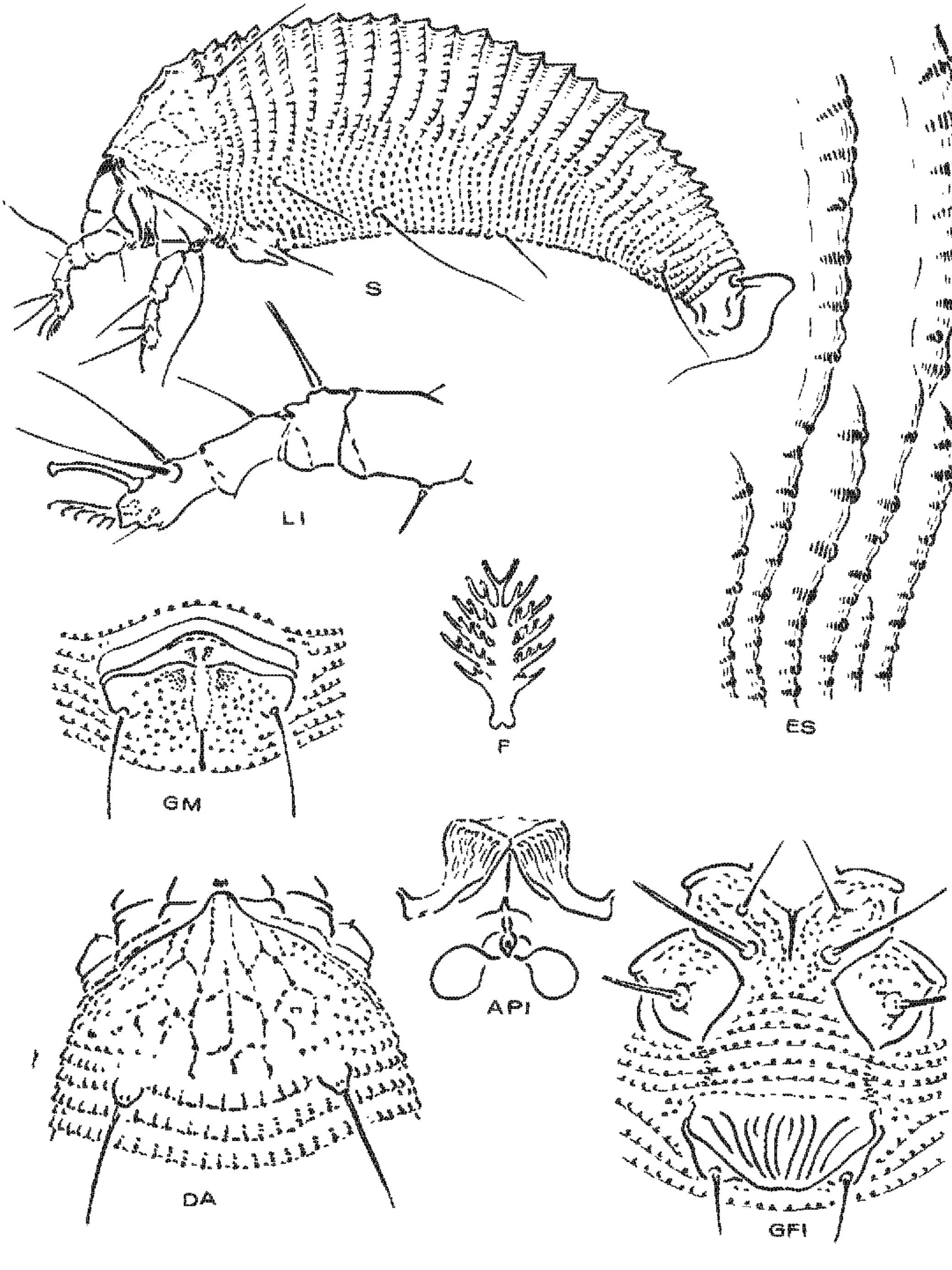


PLATE 51. *Aculops maximilianae* n. sp.

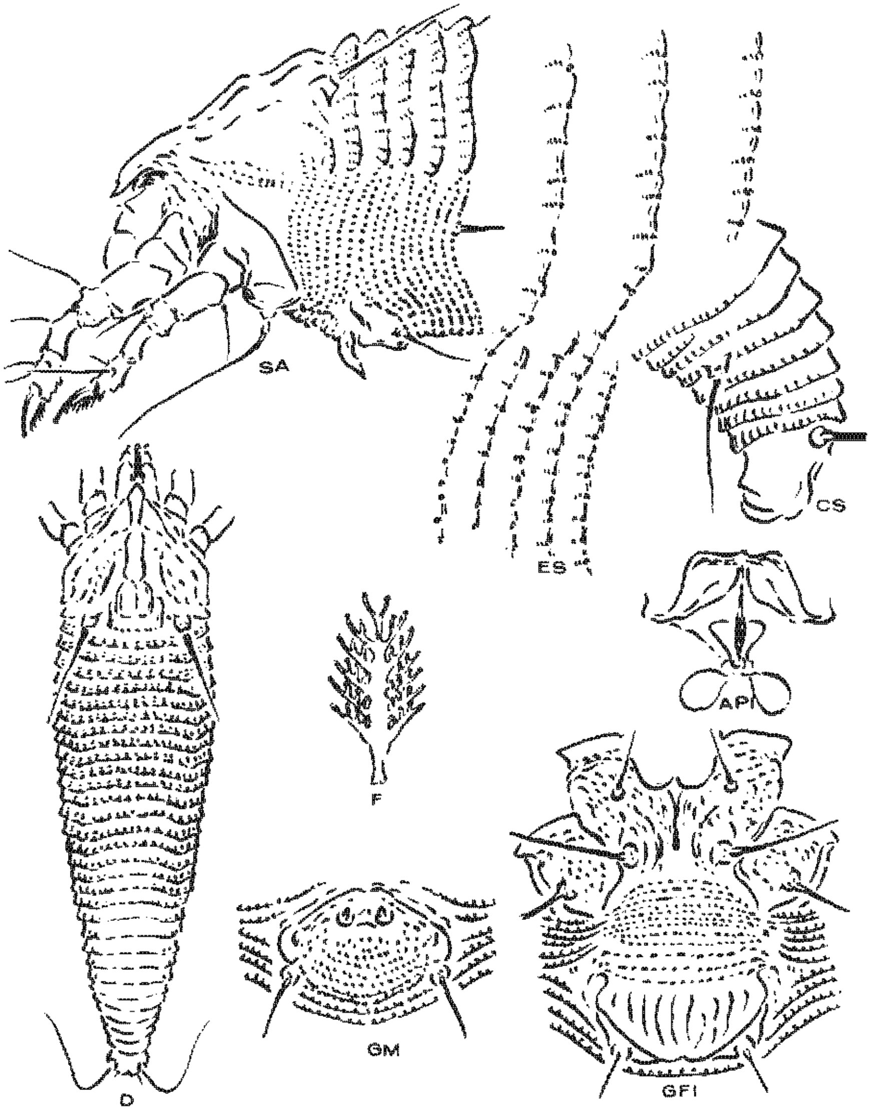


PLATE 52. *Tetra mcdanieli* n. sp.